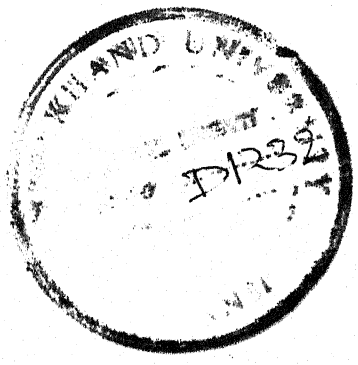
ROLE OF JOSHI'S EXTERNAL STABILISATION SYSTEM (JESS) IN THE TREATMENT OF INJURIES OF THE HAND

THESIS

FOR

MASTER OF SURGERY



BUNDELKHAND UNIVERSITY
JHANSI

2002 **M.P. SINGH**

CERTIFICATE

This is to certify that the work entitled "ROLE OF JOSHI'S EXTERNAL STABILISATION SYSTEM (JESS) IN THE TREATMENT OF INJURIES OF THE HAND" which is being submitted for M.S. (Orthopaedics) examination, 2002, of Bundelkhand University, Jhansi, has been carried out by Dr M.P. Singh personally in the department of Orthopaedics, M.L.B. Medical College Hospital, Jhansi under my guidance and supervision. The observations were checked by me periodically.

He has put in necessary stay in the department as per university regulations.

29/9/04

Prof. P.K. Dabral
M.S.
Head
Department of
Orthopaedics
M.L.B. Medical
College, Jhansi
(GUIDE)

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M.P. Singh

CONTENTS

INTRODUCTION	01 - 04
REVIEW OF LITERATURE	05 - 19
MATERIAL METHODS	20 - 33
PHOTOGRAPHS	34 - 56
OBSERVATION	57 - 71
DISCUSSION	72 - 79
CONCLUSION	80 - 82
BIBLIOGRAPHY	83 - 88

INTRODUCTION

INTRODUCTION

The history of the evolution of man may be aptly described as the evolution of hand from that of quadrupeds who use all four limbs for the sole purpose of locomotion to homo-erectus who could use hand for purposes other than locomotion.

The development of the thumb improved the prehensile nature of hand giving him the cutting edge over his simian ancestor. The, "Reach, pinch and grasp" action of the hand is well accepted as the most important function of the hand without which use of tools and consequently the growth of civilization would not have been possible. This importance of the hand can also appreciated by simply glancing at the degree of representation of a hand in the primary motor cortex (area 4 of Broadman classification) in which the hand is represented by more than half and the thumb by one fourth of the entire area. Thus it is not surprising that when it come to the treatment of thumb in hand injuries, the rule is" Save all possible".

Hand injuries are common in working men and may cause loss of income to the patient and his family, and loss of production for his employers and his country. Fortunately , an early return to work is generally the best treatment for the fracture as well as the patient once enough movement has been obtained for him to carry out his job, further progress can be expected with use.

Hand trauma has been increasing rapidly in recent years due to changes in the human environment particularly in the home, work-place, travel and leisure activities. Both the urban and the rural population are affected, the latter because of growing mechanization specially in agriculture, industry and transport.

Main aim of treatment in the hand injuries patients are :

(a) to maintain or restore the range of motion of joint.
(b) to preserve muscle strength and endurance.
(c) to enhance the rate of fracture healing by activity.
(d) to return the patient to function and employment at the earliest juncture.

when a hand injury is followed by a poor result, the worst is usually stiffness.

- Dr. Alfred B. Swanson has put it very well 'Hand' fractures can be complicated by deformity from no treatment, stiffness from over treatment and both deformity and stiffness from poor treatment'. This suggests that we must choose the treatment which is most appropriate to each particular fractures.

Fractures of hand are the most frequent of all fractures. These fractures frequently involve more than one bone of hand and hence intra articular extension, may be associated with dislocation and are usually involving the soft tissue extensively. In most of these cases conservative treatment leads to malunited fractures, unreduced dislocation and poor soft tissue care. Intramedullary fixation may lead to rotational instability, telescopy and intra medullary infection.

The use of plates and screws in hand has been shown to incite an intense fibrotic reaction with scarring, not conducive to smooth functioning of gliding structures in the hand. One indication for the use of plates and screw

would be in reimplantation and reconstructive microvascular surgery.

With the use of thin and smooth wires placed away from the site of injury, in a stable configuration created by an exoskeleton of connecting system and link joints. JESS provides a stable skeletal environment aiding rapid healing of soft tissues, and immediate mobilization of the adjacent joint. This restores circulation and prevents lymphovenous stasis leading to lesser incidence of infections.

It allows management and care of soft tissue injuries without disturbing the fracture site in compound injuries, which is not possible using the slab.

JESS also permits compression, distraction and lengthening.

The more widely used mini hoffmann fixator is costly. JESS is a cheap and easily available minifixator which has all the advantages of other fixators. It is superior to the traditional method of internal fixation by K-wire, as it allows early mobilization of injured part which is of prime importance in restoring good hand function.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Injuries of the hand have been neglected when compared to those of long bones like femur and tibia of which one can find innumerable papers despite the fact that the former constitute the largest share of fracture. As P.R. Lips Comp (1963) puts, it "Too often these fractures are treated as minor injuries , and major disability results".

Sir Reginald Watson-Jones signified the importance of these fractures when he said "An open fracture of a phalanx is no less worthy of the skill of an expert than an open fracture of the femur. There is often little difference in the economic value of surgical treatment". Similarly, sir John Charnley (1961) has said : 'The reputation of a surgeon may stand as much in jeopardy from a fracture of the proximal phalanx of the finger as from any fracture of the femur.

Various treatment modality available for injuries of hand include external splints (POP slab and aluminum and plastic splints). Internal splints such as K-wire

and small plates used in open/close reduction and more recently the mini fixator frames as the UMEX and JESS.

Though majority of closed fractures do not require accurate reduction and rigid splinting certain fractures can not be adequately reduced by close reduction such as those on volar aspect which if left as such would disturb the excursion of flexor tendons and those would need open reduction with internal fixation. Similarly unstable fractures may be difficult to maintain with external splint.

Thus in such fractures one may opt for internal fixation as described by Von Saal of New York in 1953. Though these methods may at time provide rigid fixation, they can counteract their benefit as over treatment can itself lead to stiffness and a poor result as already described. Even the most enthusiastic proponents conclude that the final results, of operative treatment can be unsatisfactory and the operation itself can very difficult.

K-wires are used extensively in small bones injuries in various configurations. Experimental work by Fyfeg is

Mason's 1979 has shown that in transverse fractures crossed oblique configuration give maximal stability. Lister (1979) introduce intra-osseus wiring of these fractures.

Malgaign and Levi employed claw-like external fixation devices for immobilization of patella. While such attempts were undertaken about 1853, the first surgeon to use a device similar to present designs was Alvin Lambotte of Belgium who published his work in 1907. This worker used percutaneous half pins with a rigid external frame on the femur and other long bones.

In England ,Charnley J. (1953) developed a simple frame for stabilization of knee jont, ankle arthrodesis and application on certain fractures.

External fixation system has been used in larger bone for many decades before Jaquet in 1976 developed the mini external fixator, which is applicable to fractures in the hand

Dicksons & Crockitt D.J. (1975) suggested that if the ulnar three metacarpals are all fractured, rigidity of fixation can be achieved by leaving the K-wire protruding

through the skin and bonding them with methyl methacrylate (MMA) and a longitudinal inter connecting K-Wire Strut.

Rosenberg L & Kon M (1986) and Scott MM (1980) and Mulligan P.J. - Use home made fixator with cement and rigid plastic tube for finger reconstruction and severe phalangeal fracture.

Shehade SI (1991) Improve the technique by forming the MMA rods inside clear plastic tubes slit open on one side and applied over the protruding K-wires. Bending the K-wires at right angles before applying the plastic tube allows the fixator to be position out of the way.

Eyres and coworkers (1993) - used charnley compression clamp attached to transverse 2 mm K. wires for treating various combinations of metacarpal fracture.

Stuchin and Kummir's (1984) Laboratory comparison of various methods showed that the commercial system have a clearly superior pin but greater

rigidity was achieved with certain configuration of reinforced bone cement.

Howard FM (1987) - They use combination of tension band wiring and an external fixator for Rolando fracture (comminuted first metacarpal base). The external fixator is used to align the comminuted fragments and to restore length and tension band wiring provide stability.

Buchler et al (1991) Discribed a technique for Rolando fracture. That combines external fixation limited internal fixation and bone grafting. He showed that in 20 displaced comminuted fractures of thumb CMC joint which were treated by external fixation 75% of patients had very. good result after follow up of 3 years. As compared with the uninvolved side, axial rotation averaged 79%, radial adduction 89%, Key pinch 88%, grip strength 81%.

Milford (1987) suggested mini external fixator for open or severely comminuted fractures of the phalanges.

Scharf W, Hertz H, Wagner M (1984) mini external fixator in the treatment of multiple fragment fractures of the base of radius and of the forearm the external fixation can also be used with good success. The external mini-fixator is a new way for external stabilization in hand surgery and can provide good results in comminuted fractures of the fingers and for finger replantation.

Schuned F, Donker Woleke M, Burny F (1984) Used external mini fixation in the treatment of 63 closed deaphyseal metacarpal fractures. A simple half frame configuration was applied in all the cases and open reduction was performed in 26%. The mean duration of external fixation was 30 days. There was none cases of nonunion and anatomical reduction was obtained in 86.6% of cases. There was no case of reflex sympathetic dystrophy. The general functional results were very good or good in 96.6% and open reduction did not significantly altered the final result. They interred that for treatment of metacarpal fractures close reduction or open reduction along with stabilization by an external fixator is a fairly useful alternative.

Dr. B.B. Joshi of Bombay , India (1988) developed a simple light external fixator system for use in fractures in hand , It came to be known as J.E.S.S. (Joshi External Stabilization System) Dr. Joshi used this external fixator system in more than 150 cases of crush injuries of hand involving soft tissue and bone in varying degrees of severity he found this assembly to be very effective in stabilizing the skeleton in functional position to allow soft tissue assessment and subsequently soft tissue healing. This system helps in tissue stabilization spontaneous revascularization and tissue expansion by gradual and controlled distraction.

Solinas S, Affanni M. (1989) Describe a new method for external fixation of phalangeal hand fractures. This method is traumatic and very easy to perform. It permitted early mobilization and good healing in a series of 20 patients.

Cziffer E (1989) designed a disposable mini external fixator, which is suitable for either provisional or definitive fixation of hand or foot fracture. The system is simple, disposable relatively radio lucent , and inexpensive. It has

been tested in an animal laboratory and has been used successfully in 27 human cases.

Sameer I, Shehadi (1991) use mini external fixator in difficult hand injury after close reduction and external fixation. In this study they exclude patients with fractures of distal phalanx, undisplaced and stable fractures and those displaced fractures where a stable close reduction could be achieved. The K-wire were introduced transversely at a 90° angle to the long axis of the bone one at the midlateral level and the second about 2 mm dorsal to the first. The kirschner wire were then fixed externally with methylmethacrylate rods, which were made by introducing the methylmethacrylate while still soft inside clear plastic tubes slit open on the side. The open side of the tube was then applied against the free ends of the kirschner wires and allowed to set in 5 to 10 minutes thus stabilizing the fracture. They utilized the plastic tubes used for packing the kirschner wires or the softener suction tubing for this purpose. They had conducted their study on 26 patients with 30 hand fracture (19 metacarpal and 11 phalangeal) treated by close reduction and

external fixation. Active range of motion exercises were started one week after reduction with the external fixtor in place. Percentage return of total range of motion in phalangeal fractures varied from 66% to 98% (mean, 84%) and in metacarpal fractures it varied from 77% to 100% (mean, 96%).

Ashmead , D - Roth et al (1992) used external fixation not only for the skeletal stabilization but also for the management of soft tissue in 29 cases of acute hand injuries. 20 of 29 Acute fracture healed and septic non union occurred.

Parson SW, Fitgerald Ja Shearer (1992) treated complex metacarpal and phalangeal fractures by shearer micro external fixator. This fixator consists of unpolished staintess steel rods which may be used singly or linked by an articulating lockable central block. The fracture may be first reduced and than fixed externally or the fixator can be applied with two rods and central block. They had carried out there study in 30 patients with 37 unstable or complex metacarpal or phallangeal fractures. In 1½ year site with minimal soft tissue tethering thus allowing early

joint mobilization with good or excellent function. Due to well recognized in appearance of radio opaque callus, the fixator was removed when union was clinically rather than radiologically evident.

Stealay Cooney et al (1992) Applied external fixator in 32 injuries of upper extremity, ten fractures of hand , 22 colles fractures and one osteotomy for made lung's deformity. In 19 patients external fixation was primary and in 14 patients it was following failure another type fixation (cast or k. wire)

Stark RH (1993) Used mini external fixator in treatment of difficult PIP joint fractures. Closed intra-articular proximal interphalangeal (PIP) joint fractures, often with accompanying joint subluxation, constitute a difficult treatment problem. This article presents an alternative method consisting of closed treatment of complex PIP joint fractures with a mini-external fixator. The method utilizes the traction principle without necessitating a complex outrigger system. Immobilization is reduced to 3 weeks and monitored with a mini-fluoro unit. The three cases presented had 1 to 2 year follow up

and excellent clinical results despite suboptimal roentgenographic appearance.

Schneider P(1993) - A simple external fixator of Kirschner wire and electric clips for use on fingers. This external fixator has been used for fifteen years and has a number of indications : Phalangeal fractures, infections and cross-finger flaps.

Nagy L. (1993) Use static external fixation of finger fractures. In spite of its similar design constructs, external fixation of finger fractures differs greatly from that of long bones. Besides its common indications in massive, high-energy trauma, and contaminated fractures, it offers true alternatives to open reduction and internal fixation and represents a superior treatment modality in well selected cases of extensive comminution. Further pending improvement in design will increase its application, although it apparently does not yet resolve long standing controversies in elective fracture care.

Schmidt I et al (1995) 25 patients with injuries of hand were treated by new external mini fixator. A specific joint bridging construction make it possible to treat severe

joint fractures by ligamentotaxis Another indication is the preoperative continuous elongation treatment in severe contractures of the fingers. The minifixator can be made dynamic and can also be used for interfragmental compression or distraction.

Pennig D et al (1995) A mini fixator system was used to assist the operative correction of soft tissue flexion contractures. The external fixator served as a tool for gradual correction and to secure joint position after soft-tissue release. Following wound healing , certain fixator components were unlocked and joint mobilization initiated. Correction involved a contraction of the first web-space as well as flexion contracture of the index, middle, ring , and small fingers. The fixator were removed after four to six weeks. The spread from thumb to index finger tip was increased from 3.5 to 16.5 cm. The functional result in sustained grip strength reached a value of 82% compared to the uninjured opposite side.

Fricker R et al (1996) Fractures of the hand and finger showing comminution or associated soft-tissue lesions are best treated with external fixation In contrast

to other systems, the new AO mini-external-fixator enables less bulky unilateral fixation facilitating early mobilization and the special design of the double clamps allow preliminary intra operation stabilization with only one wire in each fragment. Modular fixation make free replacement of the wires possible with accommodation of bone and soft tissue lesion. 20 patients with hand injury showed uneventful soft tissue healing and there were no case of non-union in 19 intracarpal and phalangeal fractures.

Drenth DJ , Klasen HJ (1998) from 1987 to 1993 they treated 33 patients with 29 phalangeal and 7 metacarpal fractures by external fixation using a mini Holfman device. There were 27 open and 25 comminuted fractures. In 12 patients one or more tendons was involved. The mean follow up was 4 years. Complications occurred in ten fractures, two required repositioning of the fixator. The functional results after metacarpal fractures were better than those after phalangeal fractures and fractures of the middle phalanx had better recovery than those of the proximal phalanx. Twenty eight of the 33

patients were satisfied with their result. External fixation proved to be a suitable technique for stabilizing unstable, open fractures with severe soft tissue injuries.

Mc Culley SJ, Hasting C (1999) The value of external fixation in certain hand injuries is well established. It particularly has a place with highly. comminuted fractures not well managed by internal fixation. Expense and availability of formal mini fixator sets have resulted in deferring method being employed. An "alternative" external fixation is presented comprising the disposable sheath of an I.V. cannula as the cross bar, held by K wire as the pins. Such basic raw material are available immediately in all theatres at minimal cost. This has been used in gun short wound with highly comminuted fractures. A preliminary study with eight patient is presented. The method is inexpensive simple to use, and quick to apply. Good bone union and length is a achieved stability is excellent, allowing early motion. They recommended this method when no standard fixator sets are available to surgeon.

Salafia A. Chauhan G (Oct Dec. 1997) use the Joshi's external stabilizing system (JESS) for the correction of proximal interphalangeal joint deformity of hand in 68 fingers in case of leprosy patients. They achieved full extension in 75% of cases and good extension in 10.3% of the cases.

MATERIAL AND METHODS

MATERIAL AND METHOD

The study was conducted on patients attending Orthopaedics Department M.L.B. Medical College, Jhansi. The patient with acute hand injuries were considered for the study.

Criteria for Selection of Patients :

Patient of all age groups, both male and female with open and closed fractures of hand were included in this series.

Pre Operative assessment :

1. History and general Examination.
2. General routine investigation.
3. Pre-operative X-ray of Local part at least in two views: Antero-posterior, 10°-30° degree oblique or lateral view.

Classification of bong injuries

A - 1. Simple
    2. Compound

B- 1. Non Comminuted
    2. Comminuted

C- 1. Intra articular
    2. Extra articular

Principles of Management -

1. Stable reduction, anatomical when possible.

2. Maintenance of length and rotation of digit.

3. Appropriate care of associated soft tissue injuries.

4. Mobilization of unsolved digits and adjacent joints.

5. Early re-establishment of tendon gliding.

6. Prevention of lymphovenous stasis.

Treatment Protocol consent of the patient -

All the patients who were taken up for surgery were told about the external fixators, procedure to bed done, the operatives post operative complications and likely results.

Anaesthesia -

In most of cases fixators had been applied under regional anesthesia combined with or without deep sedation.

Fixator Material include -

- Links joints

  Alpha clamp (upto 2 mm wire 3 mm rod)

  Beta clamp (upto 3mm wire 4mm rod)

- K.wires 1.5, 2mm , 3mm stainless steel 6"/9" longs

- Sidebars (Connecting rods)
- Distractor

In our fixator system , we reduce the cost by following methods -

1. Some times not using stainless steel rods.
2. By re utilizing the link joints.

Instrumentation :

a. Hand drill (manual)
b. T. handle
c. Pliers
d. Wire cutter
e. spanner No. 6 & 7, No. 8 & 9.
f. Allen keys 2.5 mm and 3mm.
g. Bender tubes

In closed fractures the K-wire were passed through safe zone in the phalanges and the metacarpals depending upon the indication and JESS frames were constructed on them, 1.2 to 1.5 mm K-wires were used for phalanges while 2 mm or 2.5 mm K-wire were used for metacarpals.

PHALANGEAL HOLD

Distal Phalangeal hold : Commonly used distal phalangeal hold are of three types

(a) One threaded Rod and Independent control Link joint : One K-wire is passed from dorsal to palmer side at the base of distal phalanx, proximal to the nail bed and palmer end is bend A small incision is made at the exit point on palmer aspect and K-wire is pulled on the dorsal side. Another K-wire from the tip is introduced longitudinally upto the base of the distal phalanx. The darso-palmer K-wire is connected to the threaded rod by a link joint and an independent control link joint is used to join the longitudinal K-wire to the threaded rod. The assembly is useful for applying axial traction.

(b) On threaded Rod and link joint : Intra-osseous k-wire placement is same as described previously. The longitudinal K-wire is bend 90° to dorsal side. Both the K-wire are connected to threaded rod by link joints. The hold is useful for axial traction.

(c) Traction Bow - The Anteroposterior K-wire transfixes the base of distal phalanx and longitudinal K-wire from the tip is used to gain a fixation of the phalanx in two axis.

Simple pan-Phalangeal hold : It is constructed on two K-wires one from the radial side across the base of proximal phalanges of second and third ray and another from ulner side across the bases of proximal phalanges of 5th , fourth and third rays. Protruding ends of the K-wires are joined to the frame.

Reinforced Pan-phalangeal hold : Apart from two transverse K-wires as in simple pan-phalangeal hold, one oblique K-wire is passed in each of the proximal phalanges. The transverse K-wire and oblique K-wires are joined together on a curved connecting rod.

Metacarpal holds : These are the most important segmental hold for various dynamic frames.

There are three types of metacarpal holds

1. ***Unilateral Metacarpal hold*** - There are two unilateral metacarpal holds, Radial metacarpal hold and Ulnar Metacarpal hold.

(a) *Radial Metacarpal hold* - Two parallel K-wire are passed on the lateral aspect of the hand. These K-wires are passed at the level of the base and neck engaging second and third metacarpals. The K-wires are joined to a straight connecting. rod.

(b) *Ulnar Metacarpal hold* - Two parallel K-wires are passed on the medial aspect of the hand. These K-wires are also passed at the levels of base and neck engaging fifth, fourth and third metacarpals. The K-wires are joined to a straight connecting rod.

II. ***Standard Bilateral Metacarpal hold***- It is stronger than the unilateral radial or ulnar metacarpal holds and includes features of both but one proximal pin is passed across the basis of all metacarpals. Some time two pins from either side can also be used

instead of one proximal pin one connecting rod is used on either side to join the protruding ends of the pins on either side.

III. ***Reinforced type I metacarpal hold*** - K-wires are passed as in simple metacarpal hold. U shaped connecting rods are used on either side and quadrangle frame is constructed on the top of the U shaped connecting rods.

IV. ***Reinforced Type II Meta Carpal Hold*** - Apart from proximal and distal k-wires which are passed transversely, One oblique K-wire is passed in each metacarpal.

The transverse K-wires on each side are joined as in simple bilateral metacarpal hold. Another arched connecting rod is used to join oblique K-wires to the side connecting rods. This hold is the strongest among all metacarpal holds.

THE JESS FRAMES FOR HAND FRACTURES :

Basic Concepts -

- Use static frames for all except intra-articular and juxta-articular fracture.
- Two wires must be passed in each fragment.
- If the fracture is too close to the articular surface such that it precludes the use of the joint must be spanned by the frame. At least one wire must be passed in the bone across the joint.
- Principles that apply to cantilever affix systems hold true for static JESS frames too (enhance stability by planning for maximum pin pitch, minimum free bending stretch).
- Intramedullary wires enhance stability. They may be used when the wires do not penetrate joint surfaces dangerously and in the absence of contamination/ infection. Minimum distance between wire when using alpha clamps must be 6 mm and when using beta clamp must be 7 mm.

Lateral frame - Indication Diaphyseal fractures of the phalanges and metacarpals of the index and little fingers.

Frame Construction - Fracture is reduced and held in alignment by assistant. Two transverse parallel K-wires are passed in the proximal fragment to just cross the far cortex in the coronal plane on the free borer of the digit. Similarly two transverse k-wires are passed in the distal fragment. The fracture is reduced and K-wires are spanned by a connecting rod placed 5 to 8 mm away and parallel to the lateral border of finger and clamped with alpha clamps stability can be enhanced by adding a second connecting rod parallel to the first one in mirror image configuration.

THE COLLATERAL (BILATERAL) FRAME :

Indication :

(i) Diaphyseal fractures of the middle phalanx.

(ii) Intra - articular and juxta-articular fracture of the PIP and the DIP joints.

(iii) Fracture of the thumb ray.

Frame Construction for middle phalangeal fractures - Two parallel transfixing wires are passed 6 mm apart in each fragment. The wires should be perpendicular to the long axis of each fragment and should lie in the coronal plane. Fracture is reduced manually and held by the assistant. Two parallel connecting rods one of each side of the finger are now clamped on the transfixing wires. The connecting rods are kept parallel to the axis of the digit.

Fractures of the thumb ray - Following frames are used for the metacarpal and proximal and distal phalanx fractures -

1. Dorsal oblique frame.
2. Collateral frame
3. Delta frame

Basal fractures of the thumb meta carpals - Fracture of the base of first metacarpal may be intra-articular or extra-articular.

Frame Construction - Two widely spaced parallel K. wires are passed in the distal 2/3rd of the radius on lateral aspect and two through the 2nd and 3rd metacarpals in

the same plane. Link joints are mounted over the intraosseous K-wires and all the wires are joined by a 30 degree dorsally angled connecting rod. Two K-wires are passed on the medial aspect of distal half of first metacarpal. Threaded rod is mounted over the hinge and intraosseous wires of the first metacarpal are held in place by sliding link joints and distraction nuts. This assembly allow to give gradual traction to the first metacarpal to reduce the fracture by the principle of ligamentotaxis.

The extended hand frame - The extended hand frame is used in the treatment of multiple fractures in hand, degloving injuries of hand, injuries involving the wrist joint and crush injuries of the hand.

Frame Construction - The forearm is held in supination. The first K-wire is passed in the coronal plane in the distal radius about 2.5cm proximal to radial styloid. The second K-wire is passed at similar levels through the ulna from the medial aspect in the coronal plane. A K-wire is passed in the base of the second metacarpal in the coronal plane and advanced to engage the third metacarpal. A K-wire is

passed in the neck of the second metacarpal in the same plane an advanced to engage the third metacarpal.

To immobilise the thumb in the abduction and opposition a K-wire is passed along the ulnar aspect of the thumb metacarpal at the level of the neck. These wires were connected to each other by spanning connecting rod using Beta clamp, This connecting rod is hooked on to the main extended hand frame using the short connecting rod and Beta clamps.

The next two wires are passed similarly into the fifth and fourth metacarpals from the ulnar side in the coronal plane. One in the base and one through the neck The 300 mm connecting rod is taken and bend at 20° at the level of the wrist joint. One such bent connecting rod is applied to two radial wires and to the metacarpal wire on the radial side keeping the wrist in the dorsiflexed position. Beta clamps are used to clamp the connecting rod to the K-wires Similarly another connecting rod bent to 20° of dorsiflexion at the wrist is applied to the ulnar side. A bi-axial hinge is fixed to both these connecting rods at the level of MP joints. The 200 mm connecting rod is attached

to the free joint in the hinge. Both the hinges are locked by tightening the mylock nuts keeping the MP joints in the desired position the usual position being 40° to 60° of flexion. The ends of the two extended connecting rods are spanned using the 150mm connecting rod and beta clamp.

The finger may be anchored to the frame keeping the IP joint in extension by rubber bands. Once the wound healed and if the fracture is stable mobilization can be started by shifting the rubber band to the c rod on the volar aspect of the fore arm. Thus the frame itself can be used as a dynamic splint not only for passive positioning but also for resistive exercise to strengthen the flexor and extensors.

All wounds were dressed after cleaning. The pin track were cleaned by solvent ether & rectified sprit. These were further covered by gauge pieces soaked in povidone iodine solution. Operative time varied from 45 to 150 minutes. Extra length of wire was cut short swell rubber and tubbing was sleeved over sharp edge.

Post Operative Management -

- ❖ Assessment of vascularity status.
- ❖ Analgesic and Anti inflammatory drugs.
- ❖ Antibiotics, according to pus culture and sensitivity in compound injuries of hand.
- ❖ Limb elevation
- ❖ Active and passive finger movements.
- ❖ Check radiograph, Immediately after operation. at the time of removal of JESS alone week after the fixator removal.
- ❖ Local dressing of wound and pin track dressing.

Follow Up -

Patients were followed up at 2 weekly interval till 2 month to 2½ month after fixator removal.

Main Aim of follow up -

- Assessment of function.
- Stability of apparatus.
- Complication if any
- Advice regarding physiotherapy.
- To see for union.

PHOTOGRAPHS

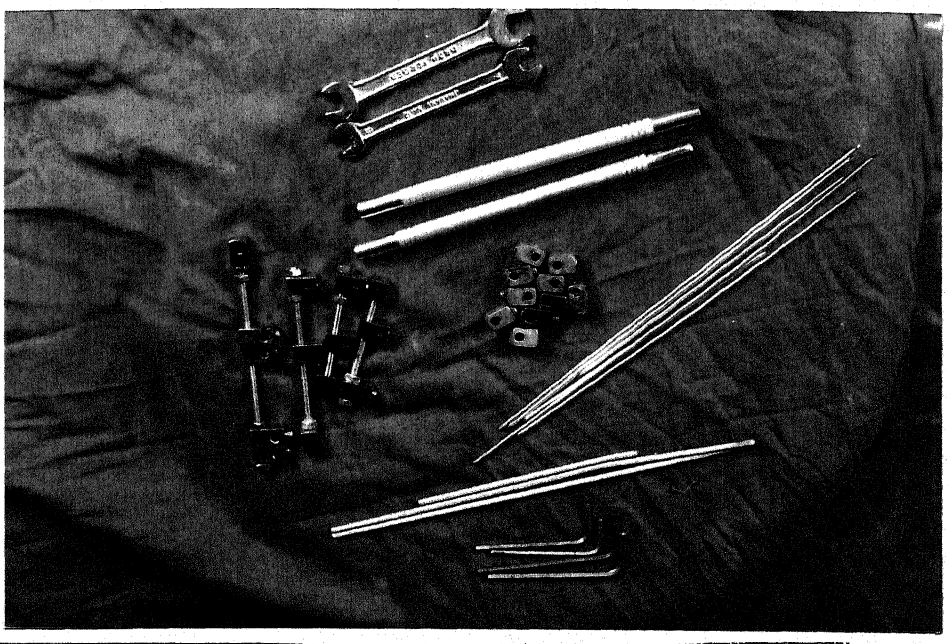


Photo No.1 : Showing implants used in JESS fixation in hand from above downwards - spanner, tube bender, distractor, clamps, K. wires, connecting rods, allen keys.

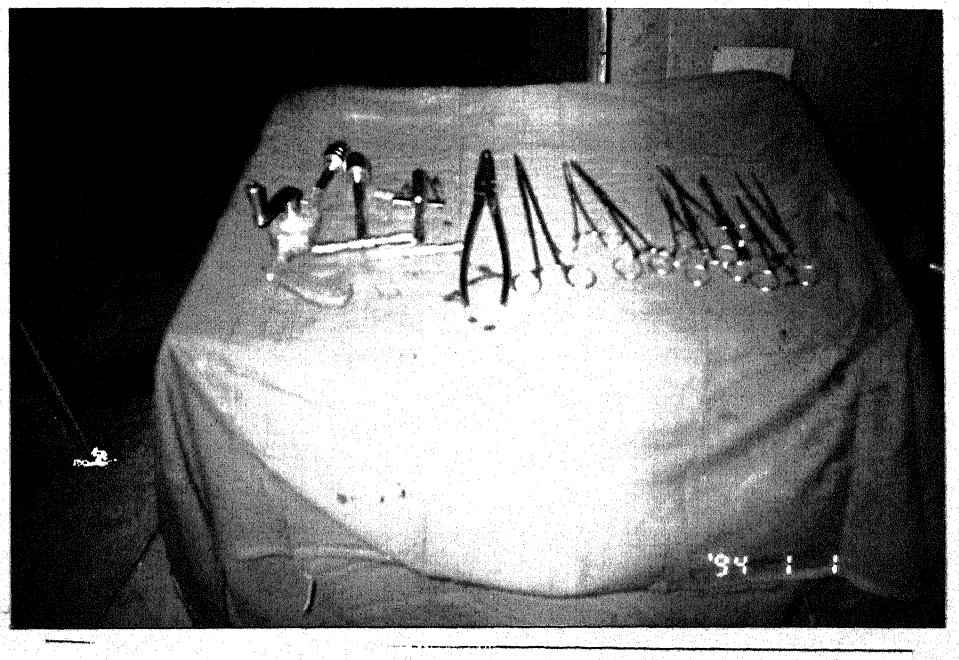


Photo No.2 : Showing instruments used in JESS fixation in hand from left to right - Manual drill, T.handle, maxpage, wire cutter needle holder, Allis forceps & various artery forceps.

Photo No.3 : X-Ray showing fracture of base of 1st metacarpal left.

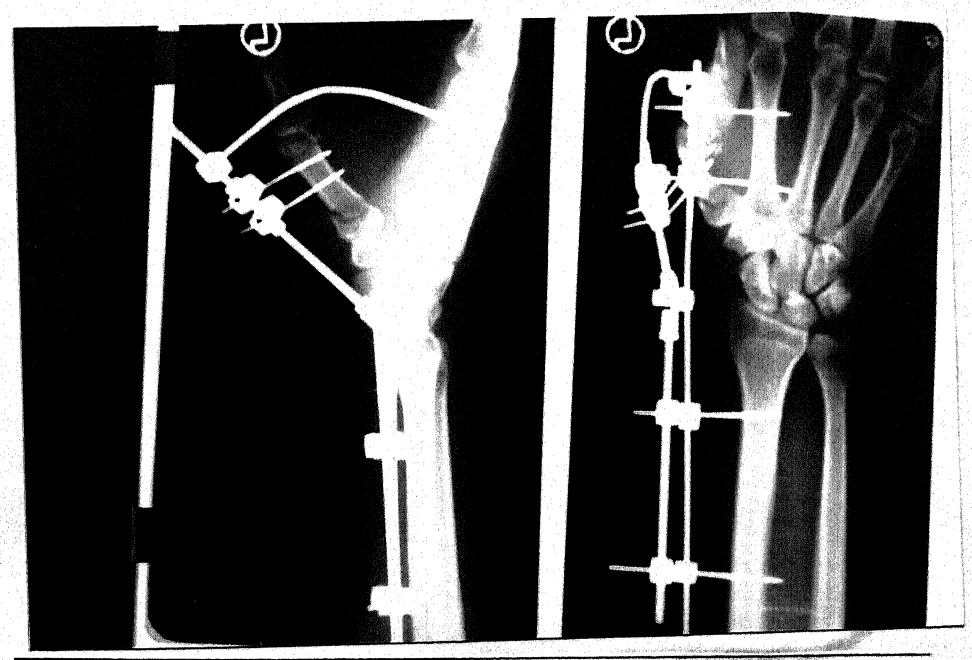


Photo No.4 : Post operative X-Ray showing 1st web space with distractor applied after close reduction.

Photo No. 5 & 6 : Same patient showing frame with good range of movement.

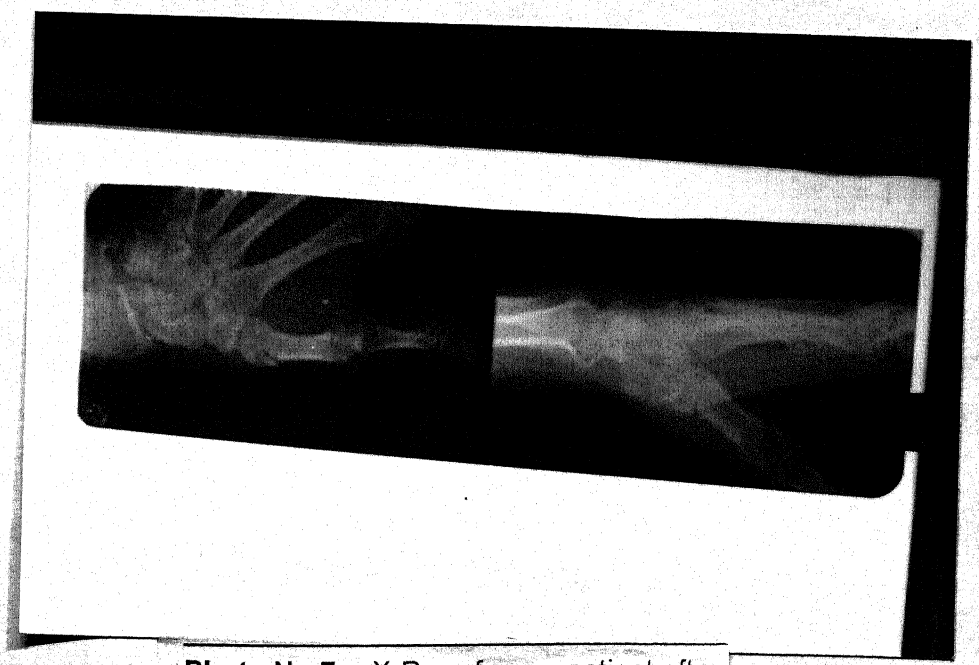


Photo No.7 : X-Ray of same patient after removal of JESS frame. union was present clinically though xRay shows no clear cut evidence.

Photo No.8 & 9 : Same patient showing full range of movements (opponens & extension) at final follow up.

Photo No.10 : X-Ray showing carpometacarpal dislocation of thumb (2 weeks old)

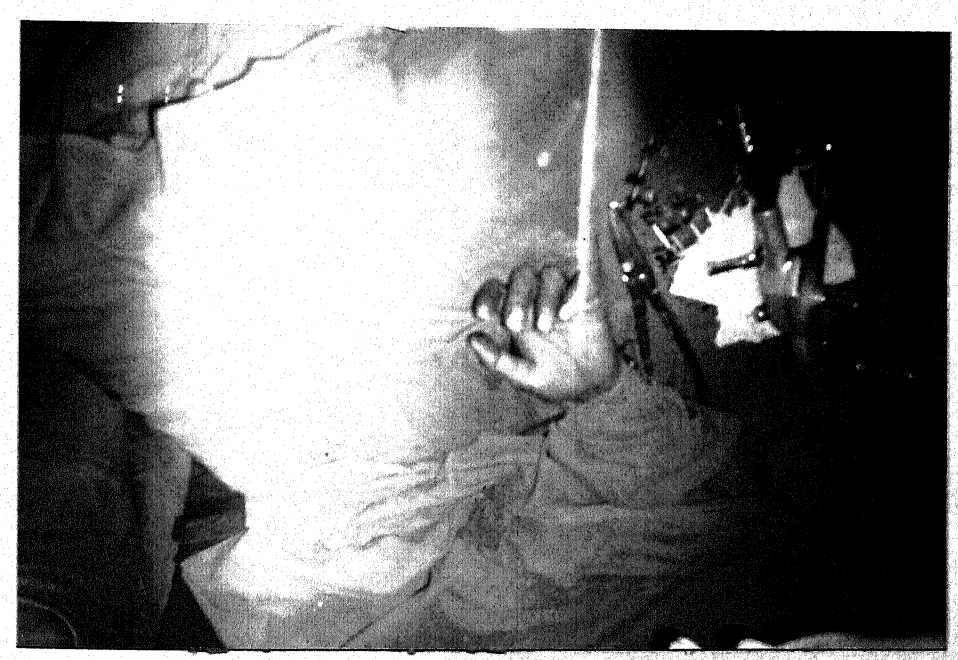


Photo No.11 : Operative preparation of the same patient.

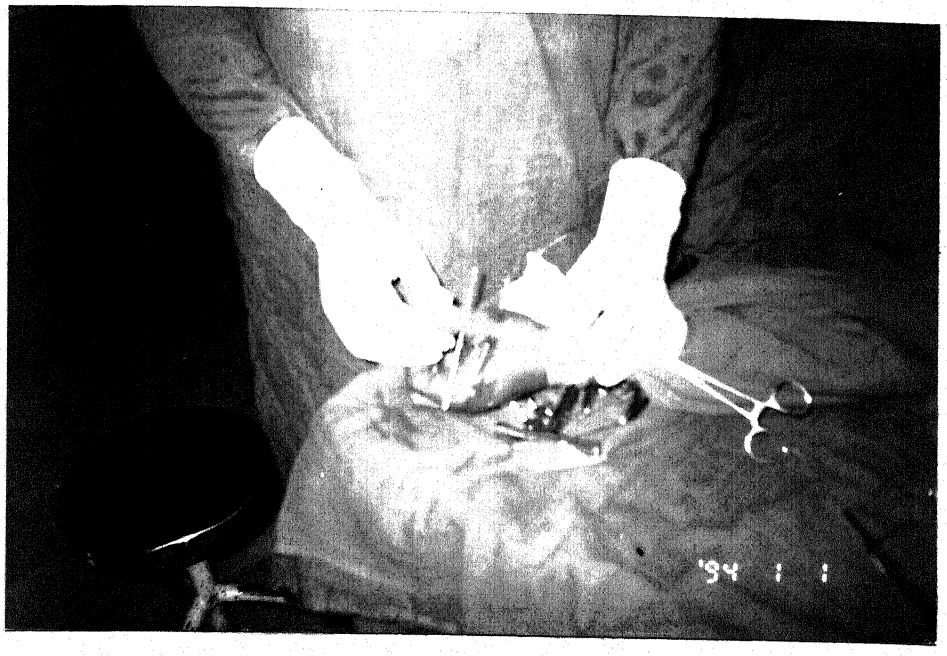


Photo No.12 : Per operative photograph of same patient showing a K wire inserted in metacarpal & proximal phalanx each.

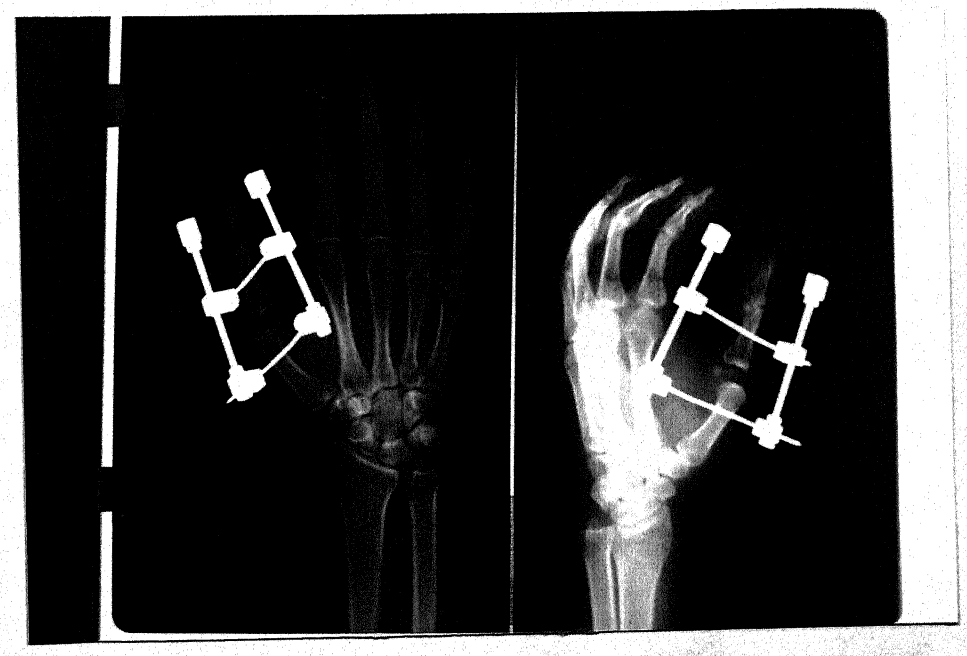


Photo No.13 : X-Ray of same patient showing corrected dislocation after gradual distraction after one week. (Increased gap was present which was corrected later on)

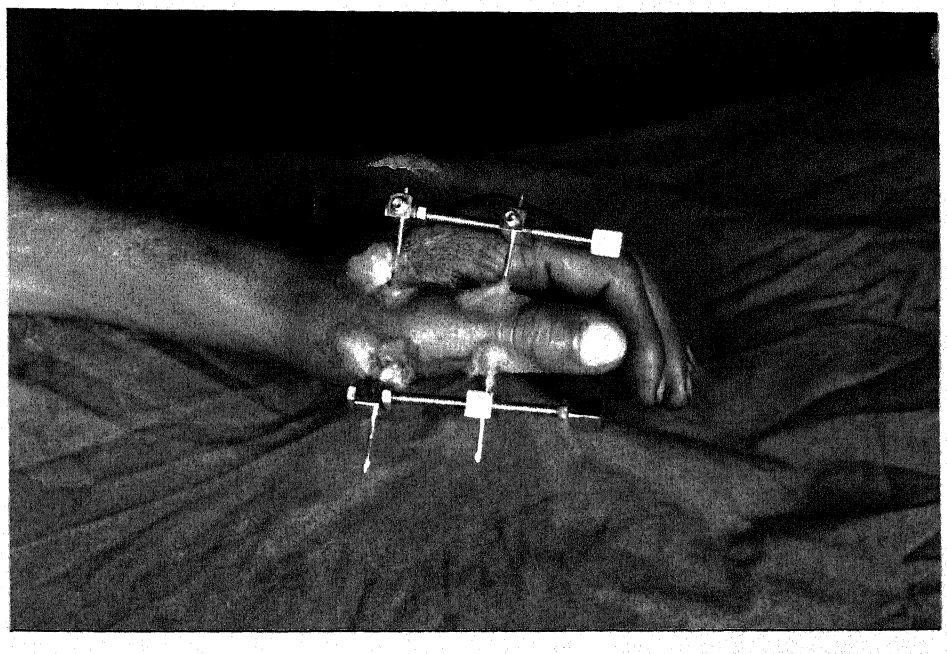


Photo No.14 : Photograph of same patient showing distractor JESS frame

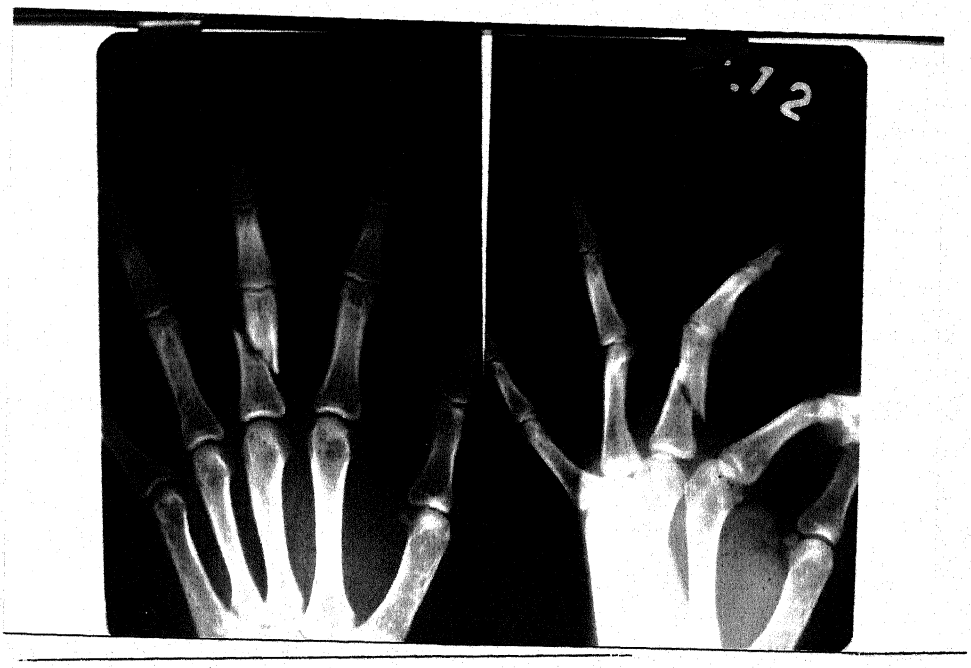


Photo No.15 : X-Ray showing oblique fracture of prox. phalanx of middle finger.

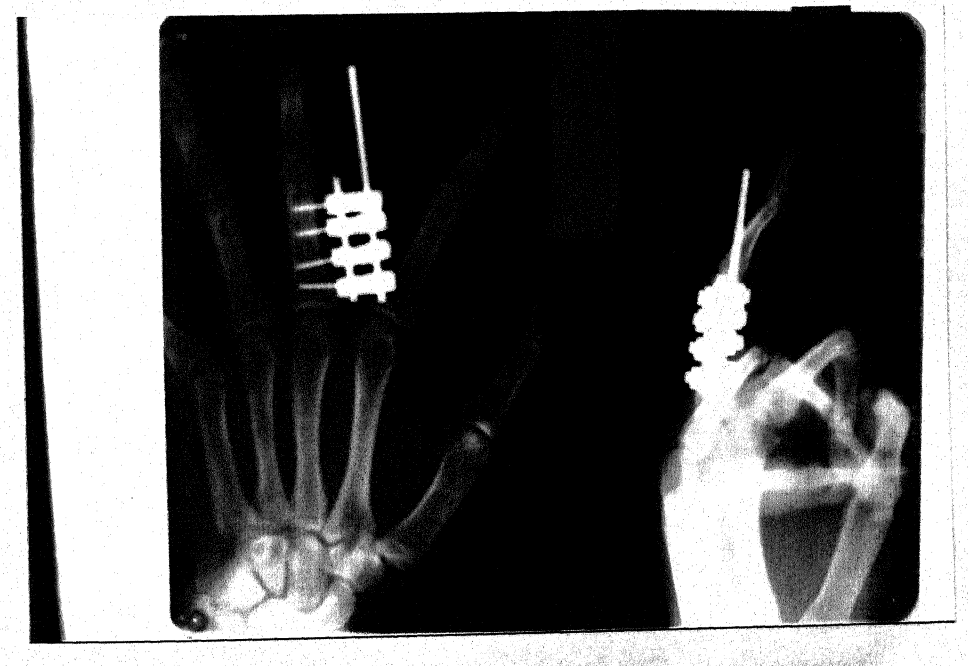
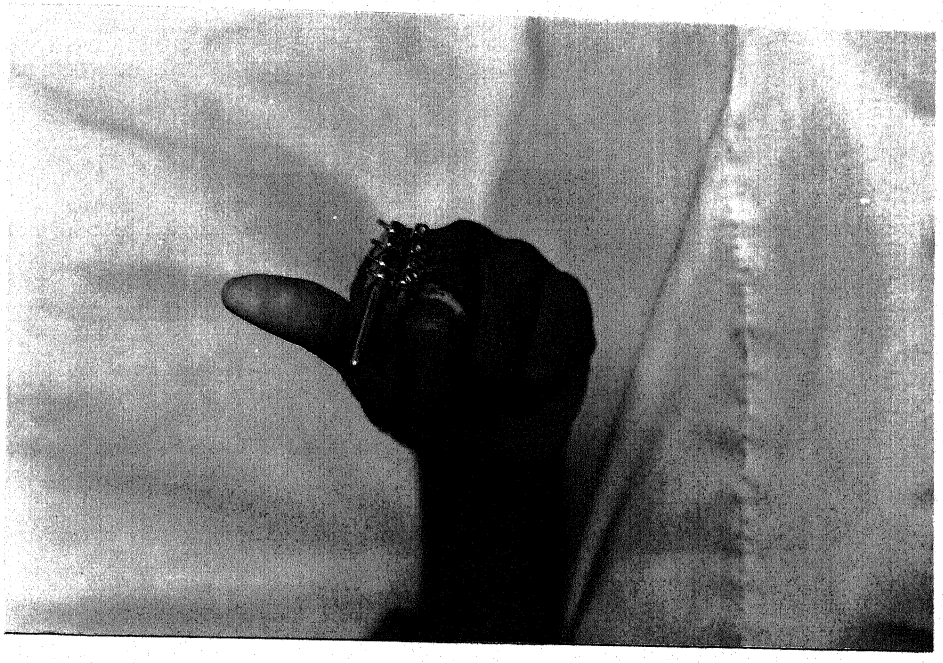


Photo No.16 : X-Ray showing acccurate reduction after dorso oblique JESS frame.



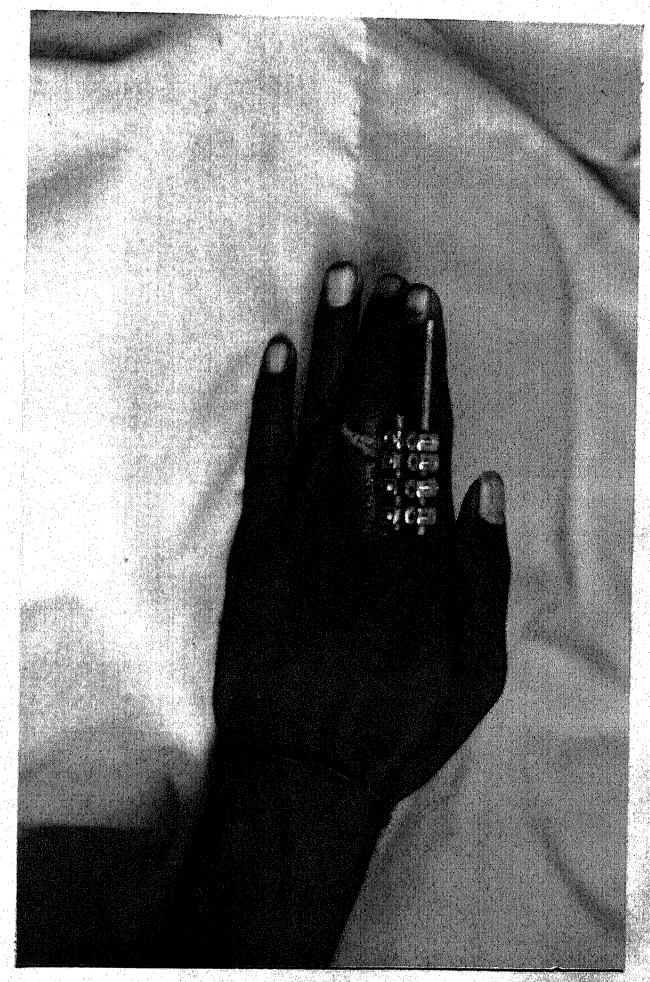


Photo No.17 & 18 : Photograph of same patient showing full range of movements presents inspite of JESS frame.

Photo No.19 : X-Ray showing communited fracture of proximal phalanx of index finger.

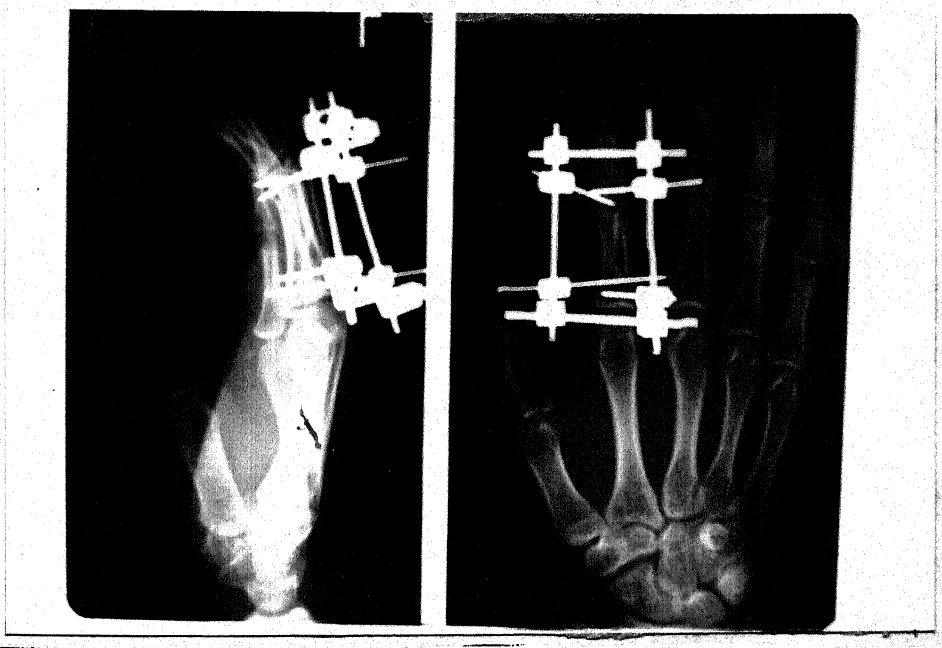
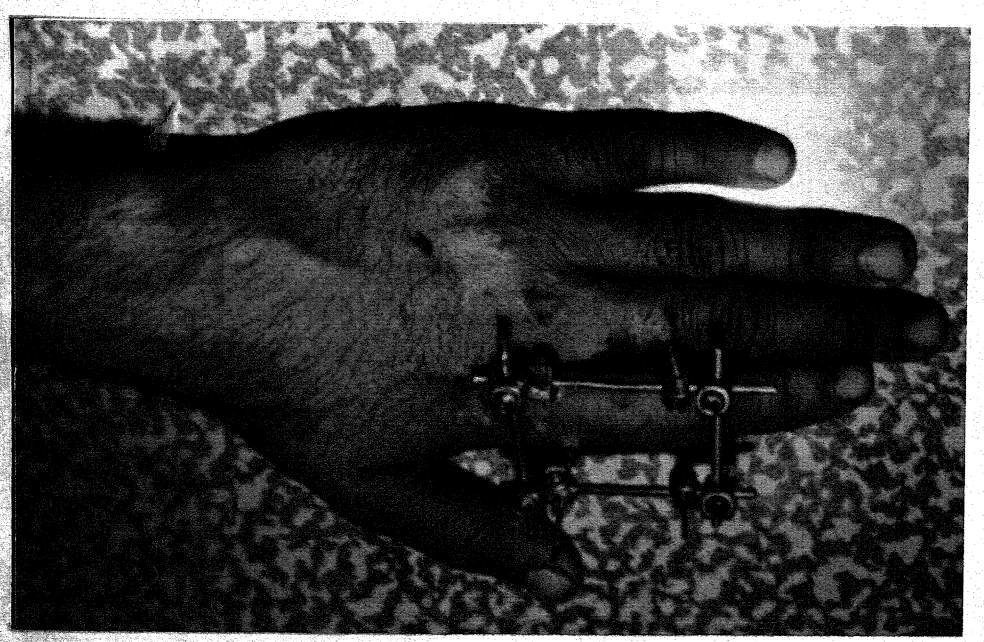


Photo No.20 : X-Ray showing delta frame applied after closed reduction & correction of deformity acheived.



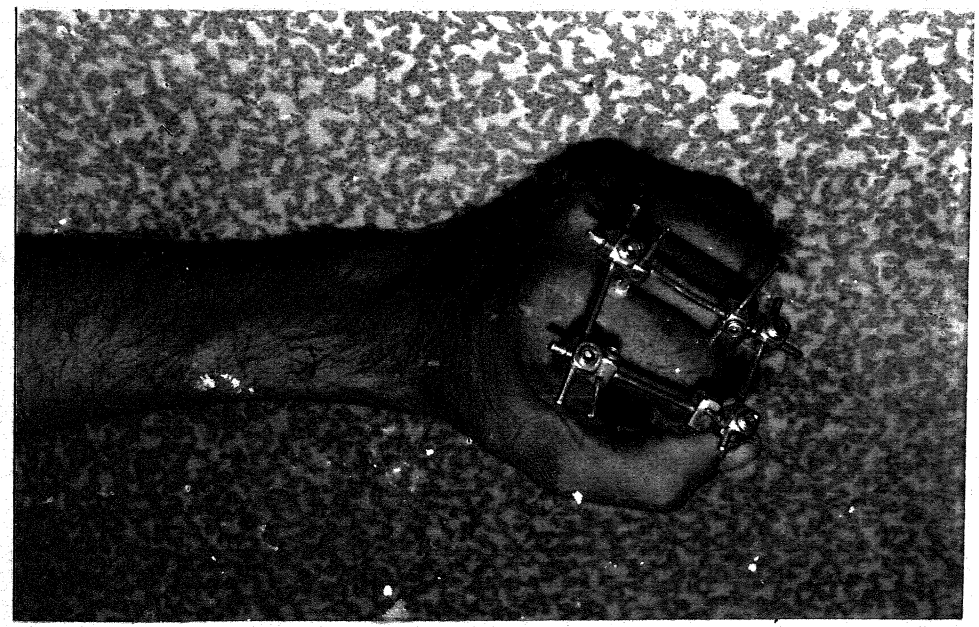
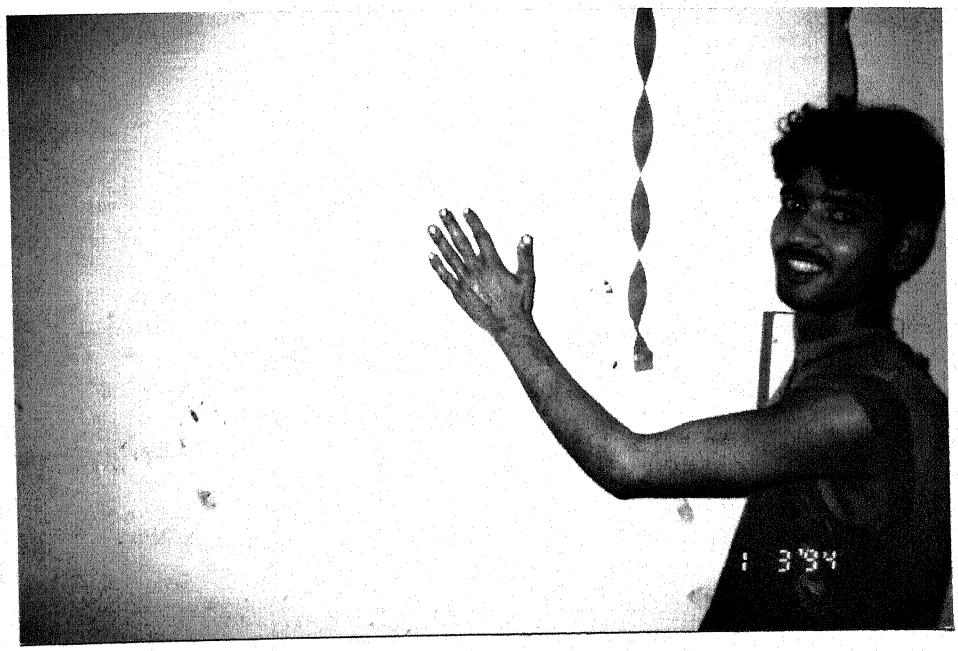


Photo No.21 a & b : Photograph of same patient showing good range of movements & possibility of active physiotherapy after applicatin of delta frame.



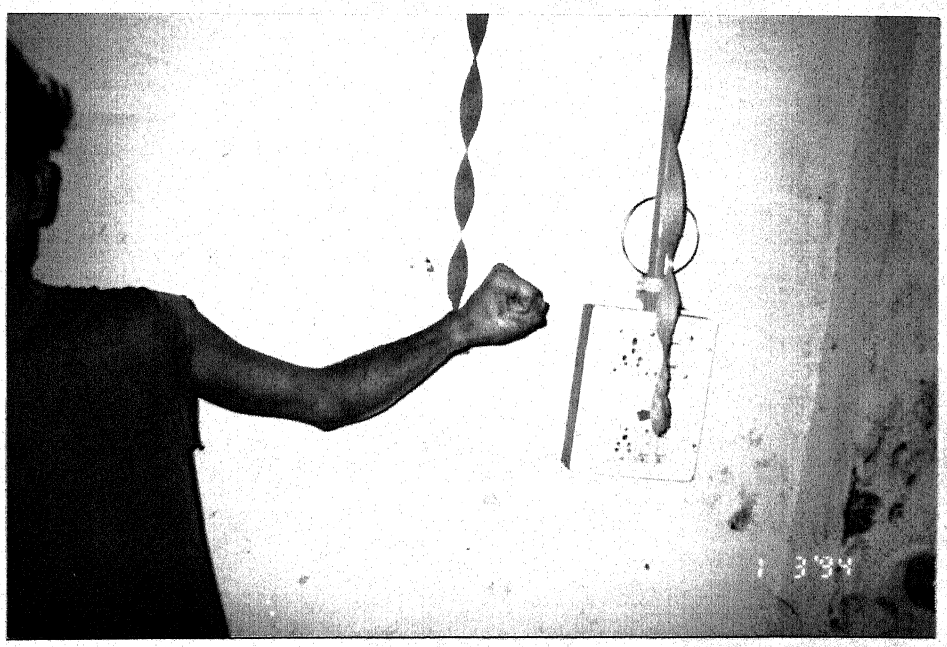


Photo No.22 & 23 : Same patient showing full range of movement at final follow up visit.

Photo No. 24 : Showing Fracture of Third , Fourth & Fifth Metacarpal

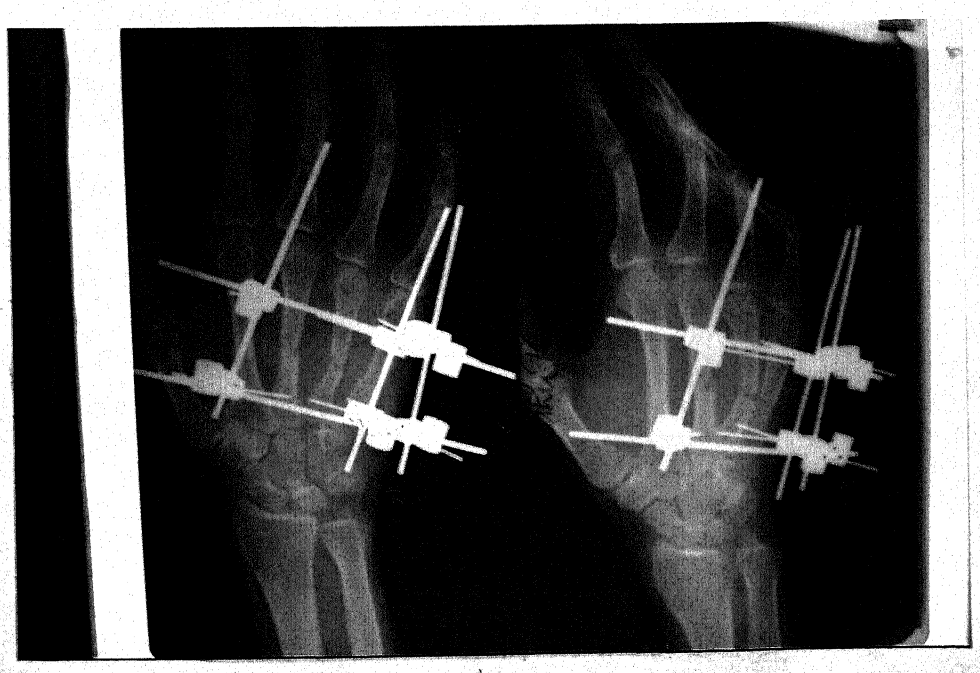
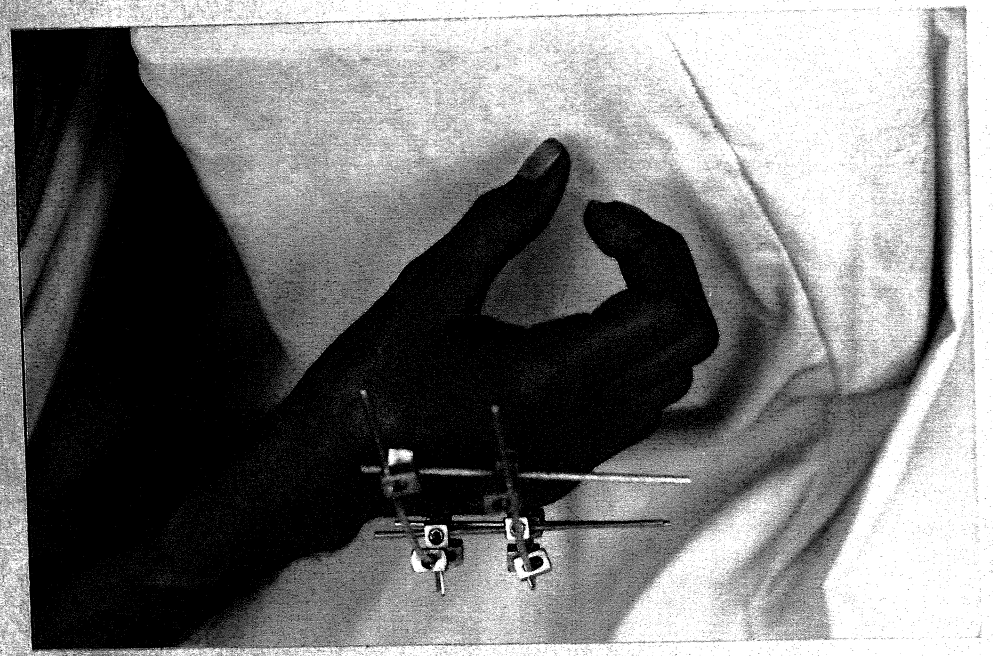


Photo No.25 : X-Ray showing corrected rotation with small degree of angulation at 4th metacarpal after metacarpal hold frame.



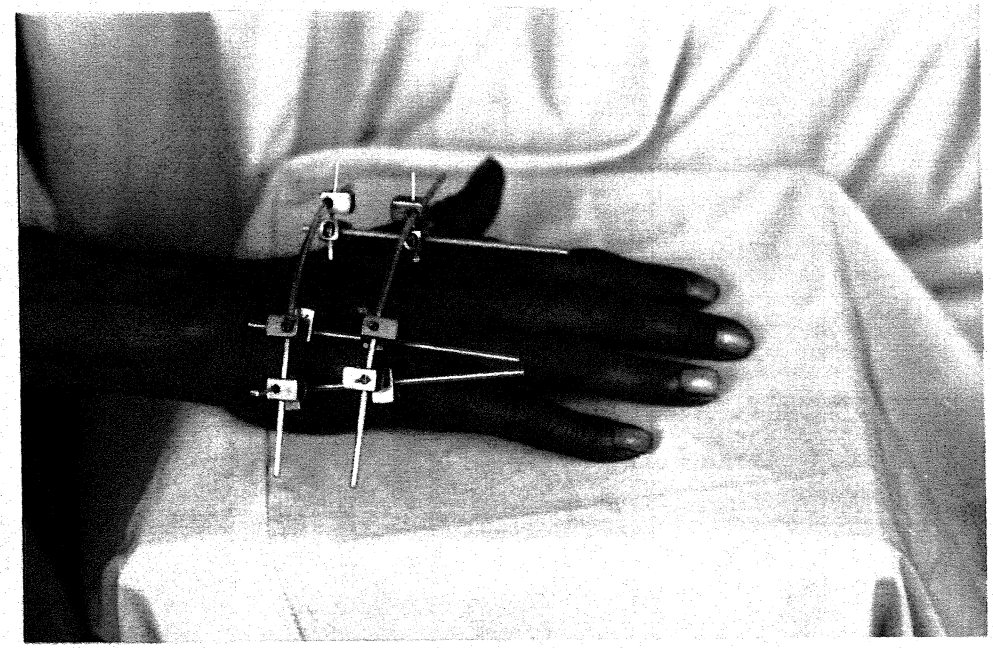


Photo No.26 & 27 : Same patient showing adequate functional range of movements in metacarpal hold frame.

Photo No.28 : X-Ray showing prox. phalangeal fracture of little finger with overiding deformily.

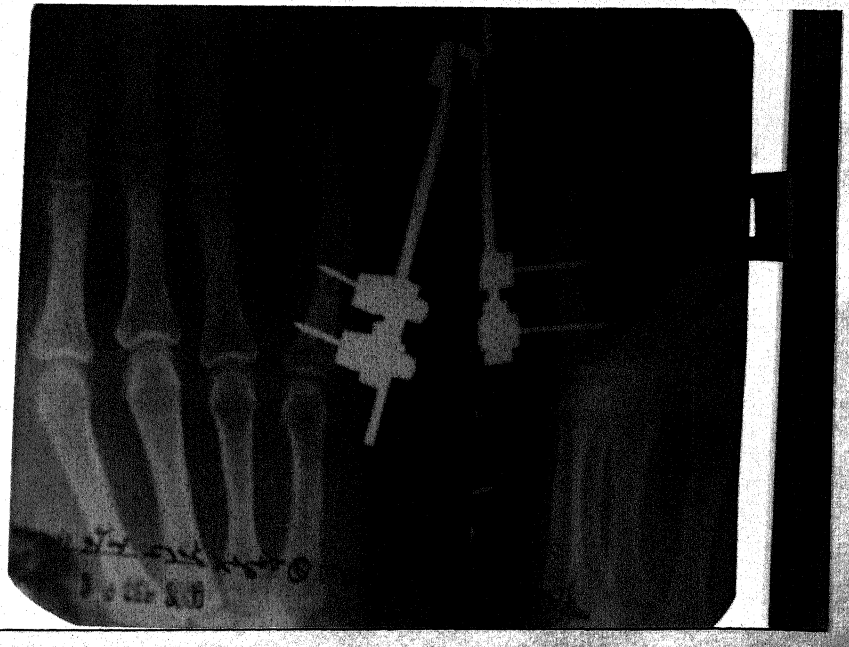
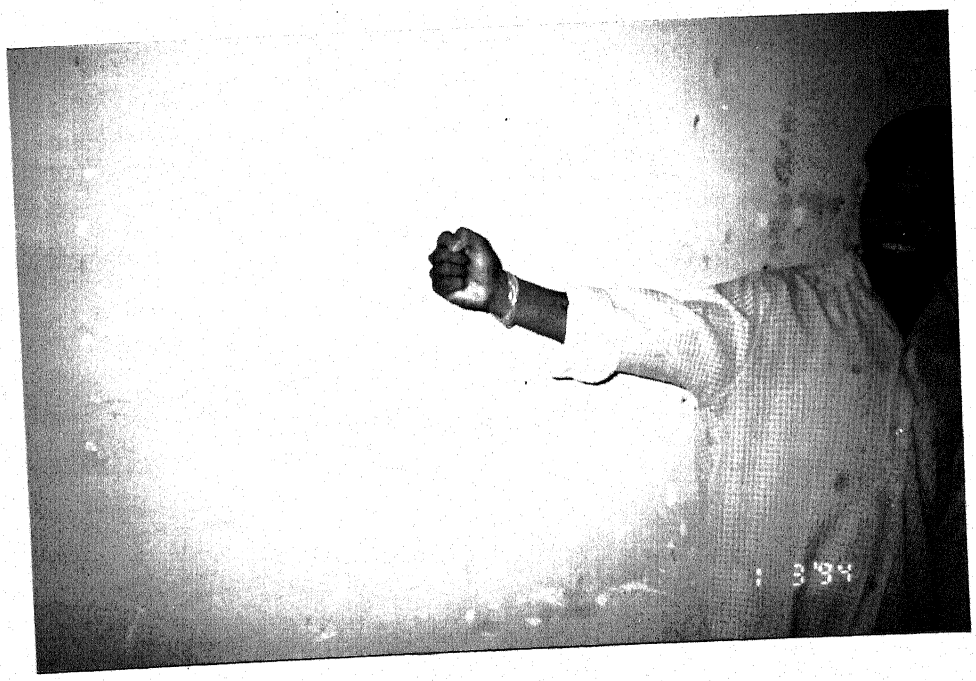


Photo No.29 : X-Ray showing complete correction of rotation & over riding deformity by gradual distraction.



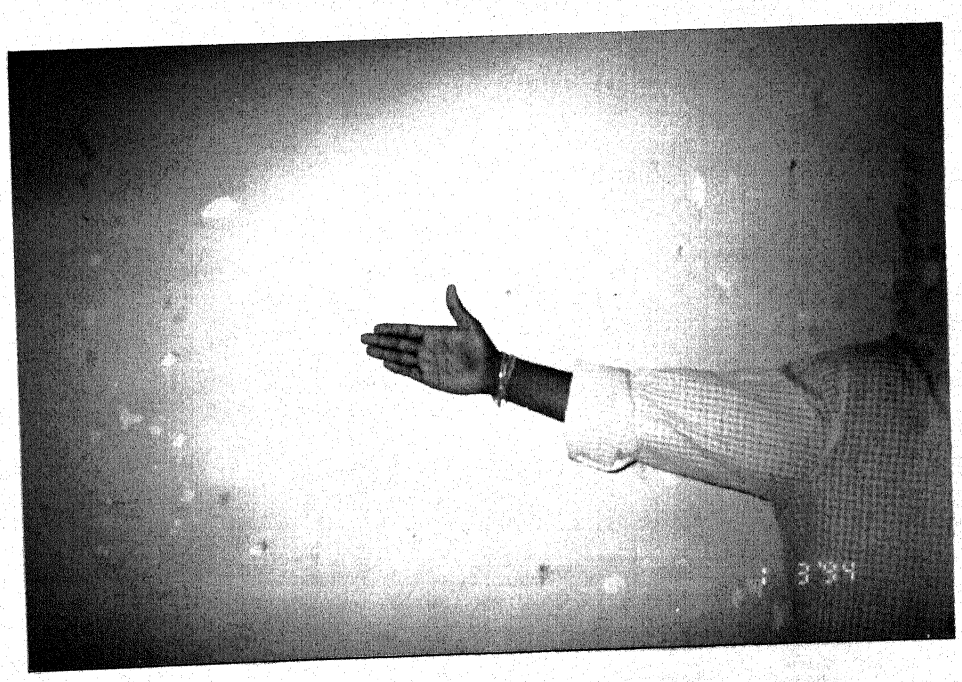


Photo No.32 & 33 : Photograph showing full range of movements in same patient at final follow up.

Photo No.34 : X-Ray showing fracture of base of first metacarpal.

Photo No.35 : X-ray showing post reduction status after distractor frame.

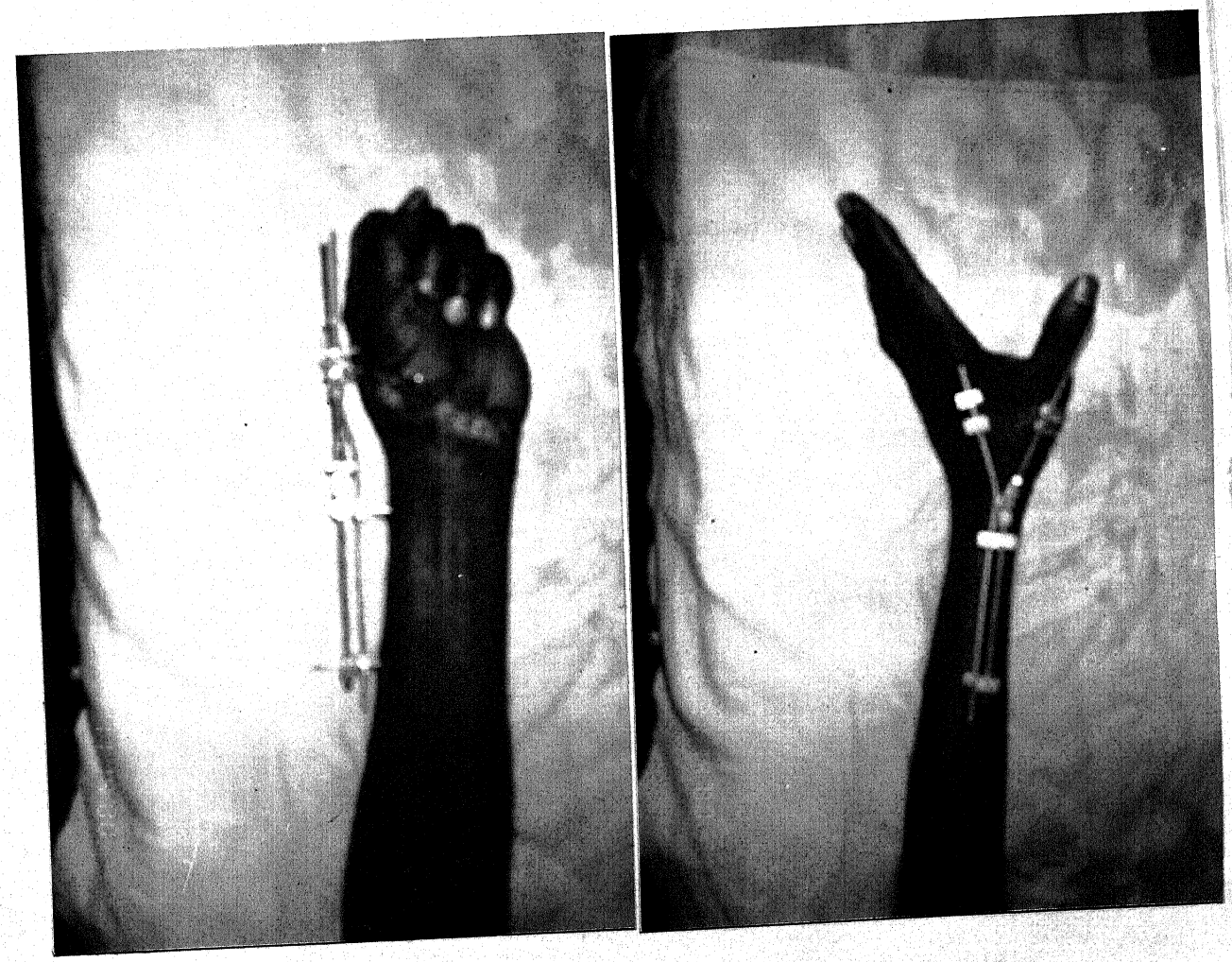


Photo No.36 & 37 : Photograph showing good range of movement even after compounding, wound healed within two weeks.

Photo No.38 : X-ray showing multiple fractures of small bones of hands after thresher injury.

Photo No.39 : X-ray showing correction of deformities after application of extended hand frame.

Photo No.40 : Photograph of same patient, whose hand was severely crushed by thresher and hand was saved because of JESS frame, extensor tendons were repaired. Split thickness skin grafting was done after two weeks of JESS fixation. Loss of movements of little degree was present at final evaluation even after physiotherapy.

Photo No.41 : X-ray of a patient after road traffic accident showing fracture of prox phalanx of 4th & 5th fingers.

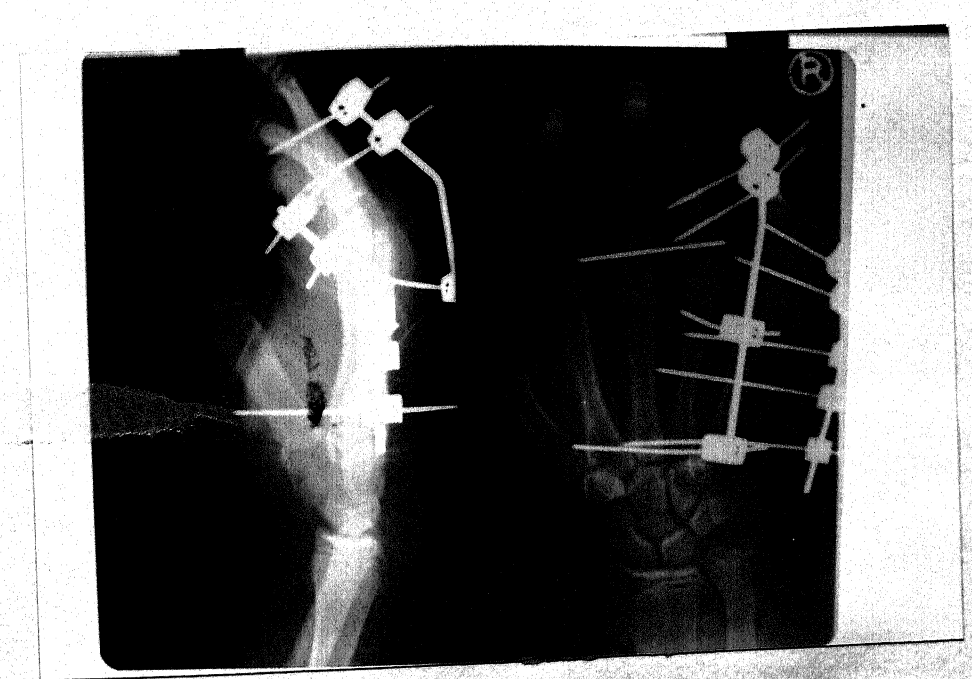


Photo No.42 : X-ray showing post reduction status in ray frame.

OBSERVATION

OBSERVATION

WE DEALT WITH SIXTEEN CASES OF HAND INJURIES.

ALL OF THEM WERE TREATED BY JOSHI'S EXTERNAL STABILIZING SYSTEM.

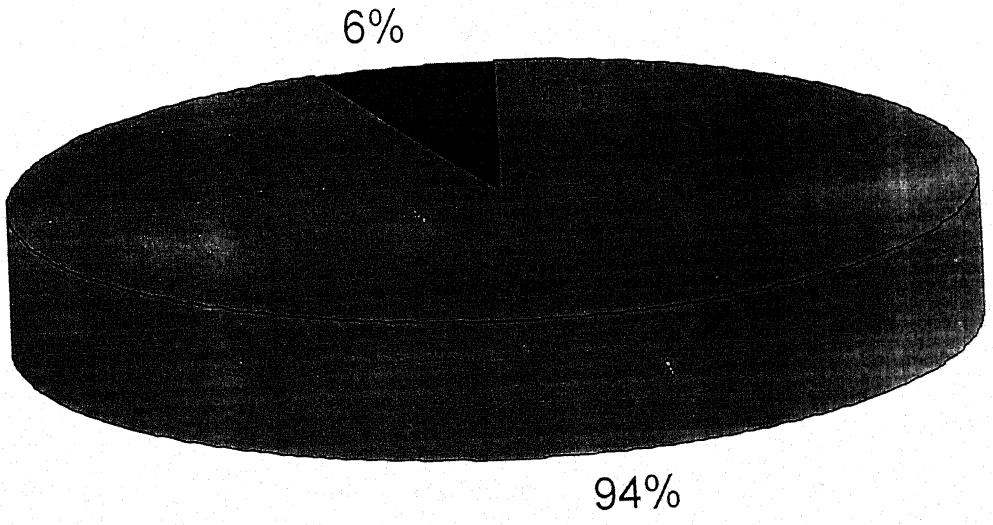
Table No 1

Sr No	Age (Yrs)	Cases	Percentage (Aprox)
1	10-20	3	19
2	21-30	3	19
3	31-40	7	43
4	41-50	2	13
5	51 & Above	1	6
	Total	**16**	**100**

(AGE DISTRIBUTION)

In our study the maximum incidence of injuries was found between 31-40 years of age group (43%)

(SEX DISTRIBUTION)



In our study Pie chart shows males (94%) were affected more.

Table No 2

Sr. No.	Duration	Cases	Percentage
1	< 1 day	8	50
2	1-5 days	5	31
3	6-10 days	2	13
4	11-15 days	1	6
	Total	**16**	**100**

(DURATION OF INJURY)

In our study the maximum (50%) of cases presented in the hospital on the same day of injury.

Table No 3

Rays	Cases	Rays	Cases
R1	2	L1	5
R2	-	L2	2
R3	2	L3	3
R4	5	L4	1
R5	5	L5	-

(RAYS INVOLVED)

The most common ray involved in our study population were R4, R5 and L1

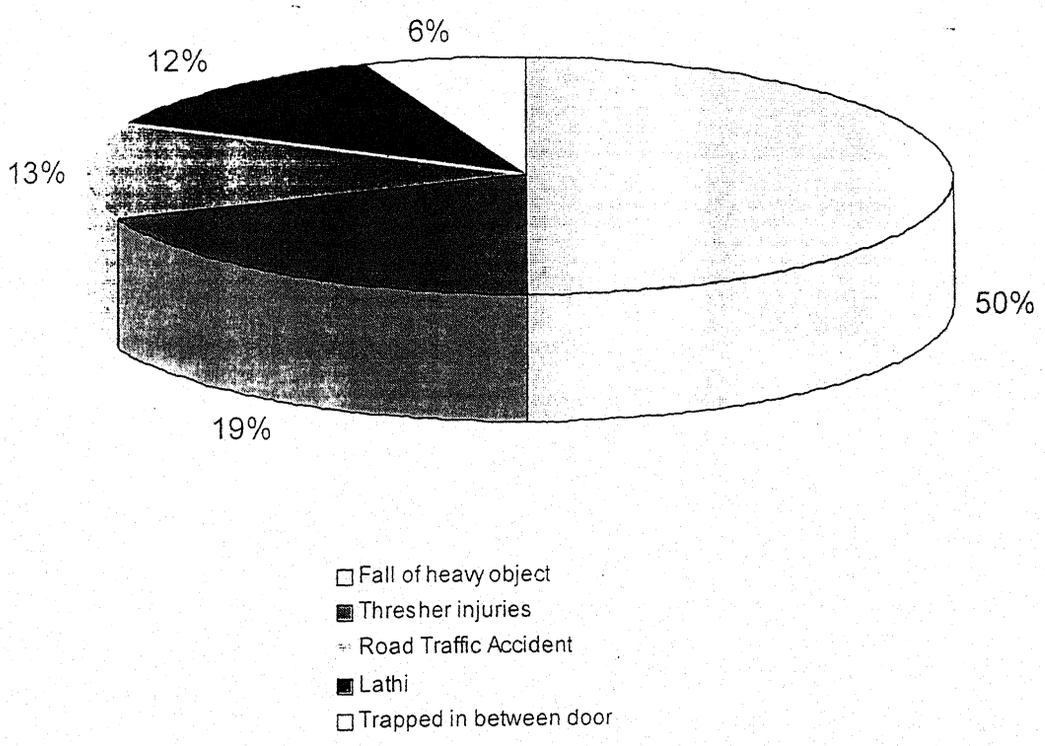
Table No 4

Joint	1	2	3	4	5
M.P.	1	-	1	1	2
PIP	-	1	1	-	-
DIP	-	-	-	-	-

(JOINT INVOLVED)

The most common joint involved in our study was M.P. joint of little finger.

(MODE OF INJURY)



In our study the majority of cases (50%) were due to crush injury produced by falling heavy objects such as stone while on work. This was followed by 19% of cases due to thresher injuries. Road side accidents and medicolegal injury together constituted 25% cases.

Table No 5

Sr. No.	Condition	Cases	Percentage (Aprox)
1	Crush Injury	9	56
2	Swelling	5	31
3	Swelling + Laceration	2	13
	Total	**16**	**100**

(CONDITION OF INJURED PART)

In our study the most common presentation at the time of admission was crush injury of the hand (56%)

Table No 6

GRADE	I	II	III
CASES	1	4	5

(GRADE OF COMPOUND)

In our study total cases of compound injury were 10 out of which maximum number of cases belong to grade III.

Table No 7

Sr. No.	TYPE	CASES	PERCENTAGE
1	Distractor	6	37.50
2	Extended hand frame	2	12.50
3	Uniplaner frame	2	12.50
4	Ray frame	2	12.50
5	Delta frame	1	6.25
6	Biplaner frame	1	6.25
7	Metacarpal hold	1	6.25
8	J frame	1	6.25
	Total	16	100

(JESS FRAMES)

The most common type of JESS used in our study population was Distractor (37.50%)

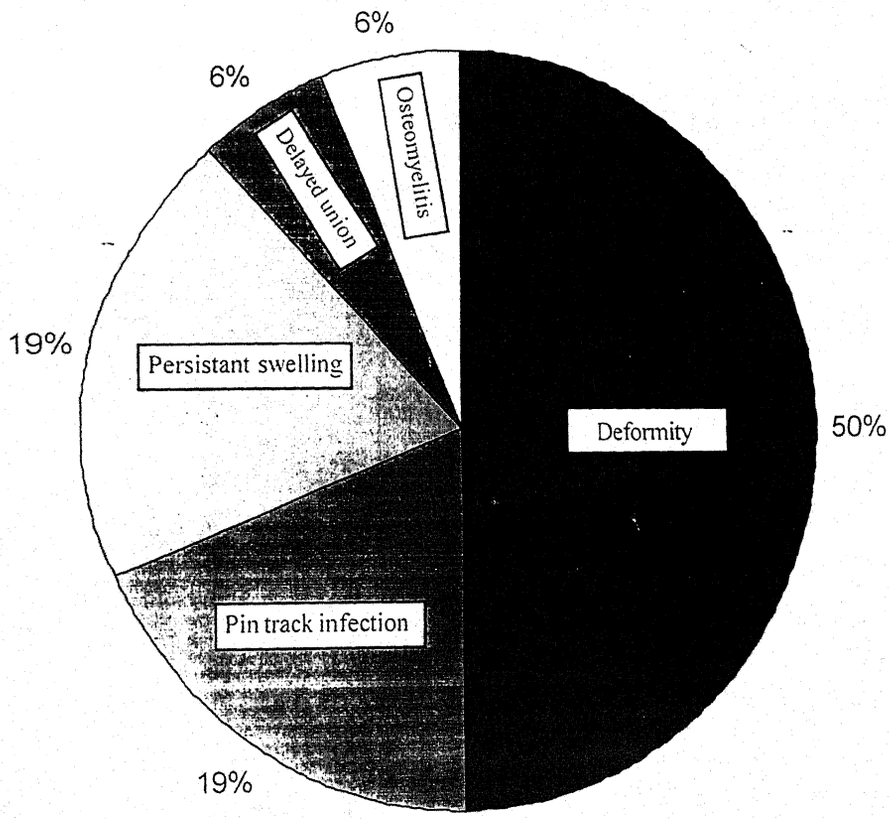
Table No 8

Sr. No.	Name of Operation	Cases
1	Debridment with External fixator	10
2	Distraction	6
3	Split thickness skin grafting	3

(OPERATION REQURIED IN MANAGEMENT)

In our study most of the compound injuries required early debridment.

(COMPLICATION)



In our study the complication shown in Pie chart represent that at the time of removal of fixator some degree of deformity (50%) persisted due to stiffness. Pin track infection was seen in about (19%) of cases which healed within a weak.

Table No 9

Sr. No	DAYS	CASES	PERCENTAGE (Aprox)
1	> 21	5	31
2	30	7	44
3	35	1	6
4	40	1	6
5	45 and above	2	13
	Total	**16**	**100**

(TIME OF FIXATOR REMOVAL)

In our study majority of fixators were removed between 30th to 35th day.

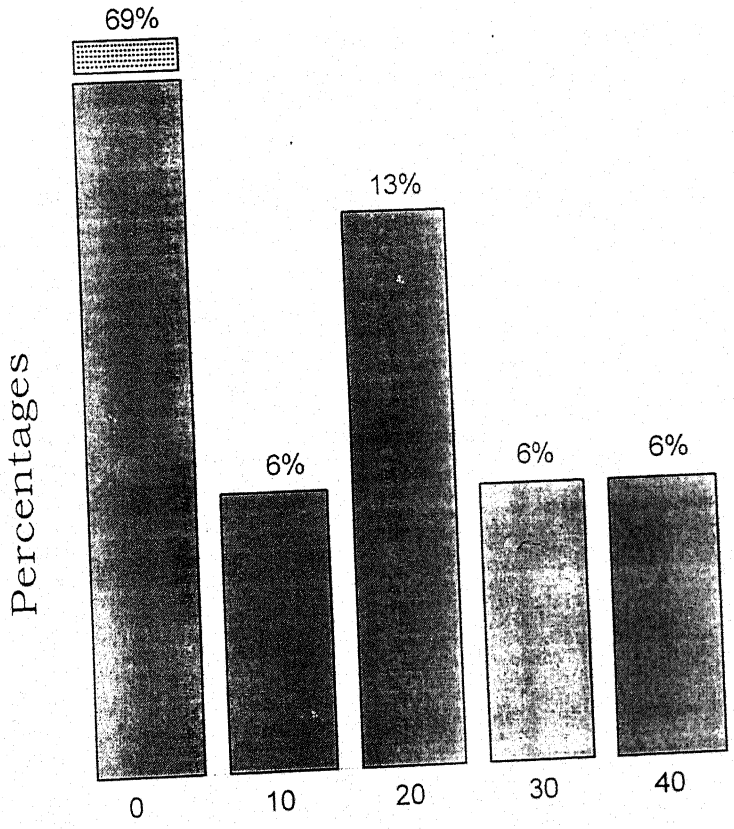
Table No 10

Sr. No	DAYS	CASES
1	< 15	5
2	16-25	2
3	26-30	2
4	> 30	1
	Total	**10**

(WOUND HEALING)

In our study wound healing took place maximally within 15 day.

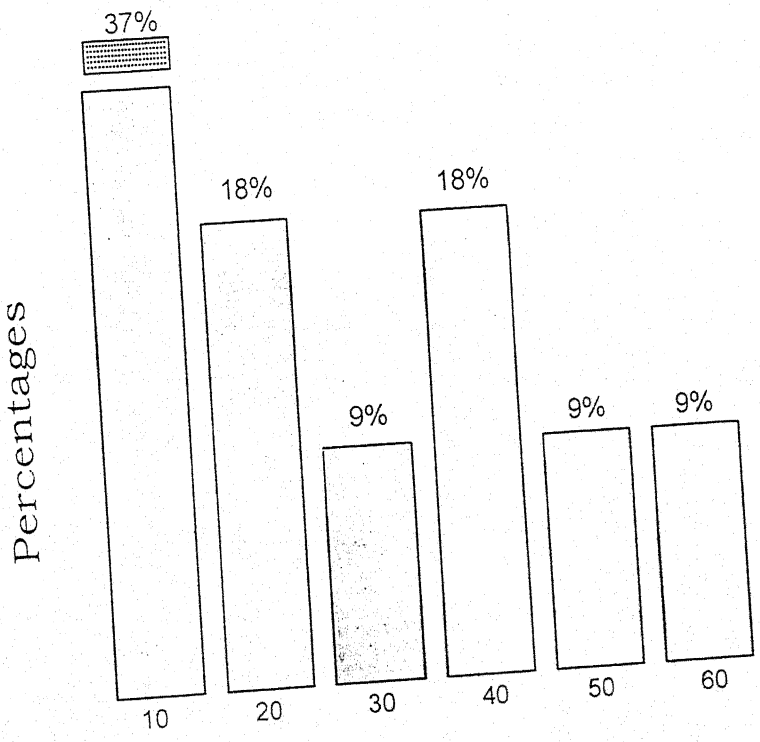
Differences in active movement present at M.P. joint in uninvolved and involved Ray at final follow up



Difference in movements (in degree)

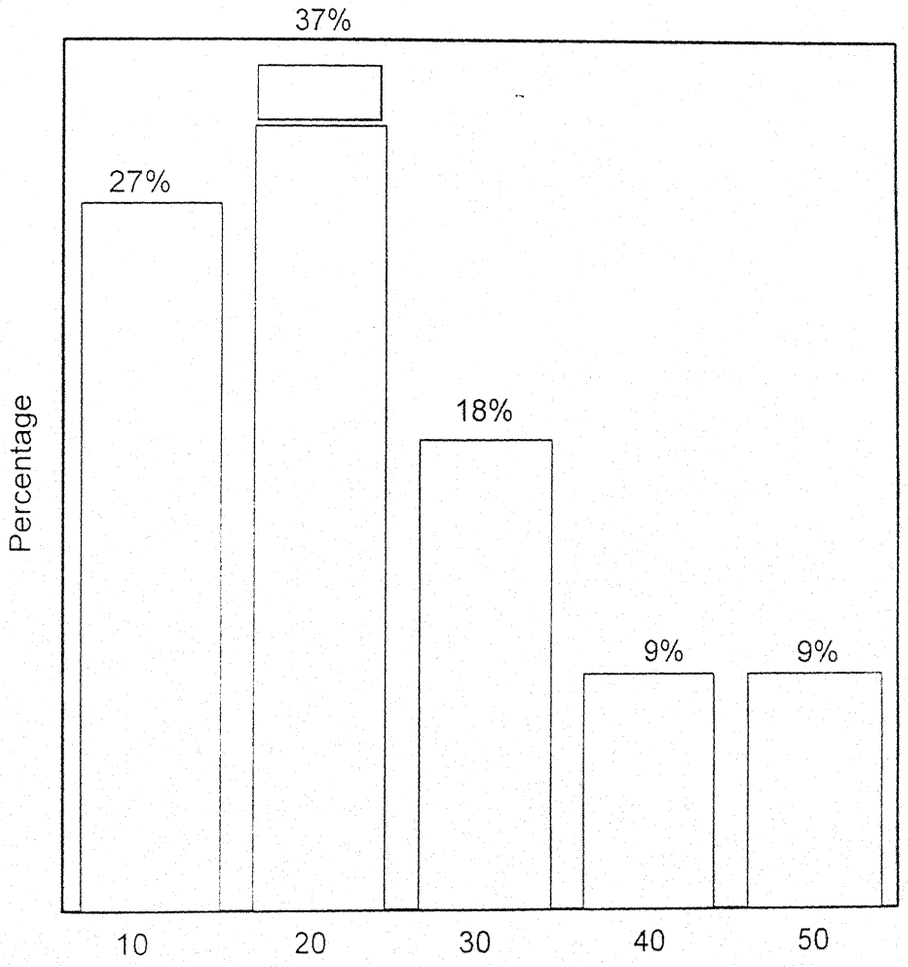
Above bar diagram shows that 69% of MP joints regained their movement at final follow up.

Differences in active movement present at P.I.P. joint (in 11 cases) in uninvolved and involved Ray at final follow up



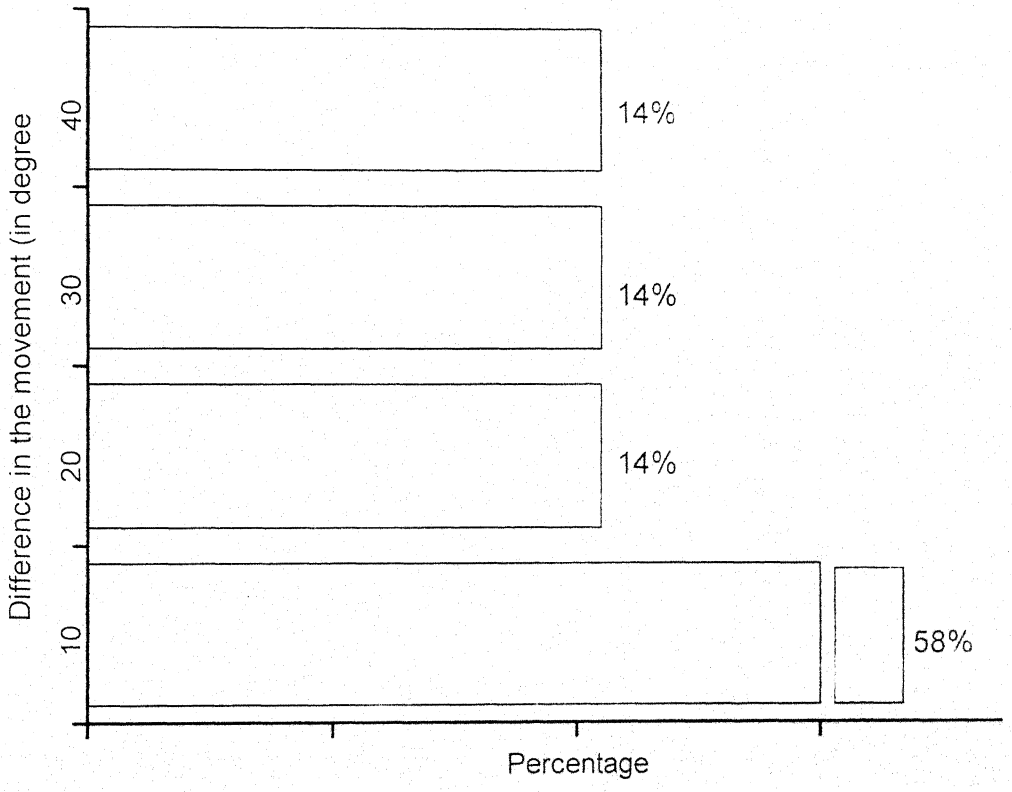
Above Bar diagram show that 37% of patients had differences of above 10^0

DIFFERENCE IN ACTIVE MOVEMENT AT DIP (IN 11 CASES) AS COMPARED TO UNINVOLVED RAY (DEGREE)



Above bar diagram shows that about 37% of the patients had difference of movement of around 20°.

DIFFERENCE IN ACTIVE MOVEMENT PRESENT AT IP JOINT OF THUMB (IN 7 CASES) AS COMPARED TO UNINVOLVED RAY (DEGREE)



Above bar diagram shows that 58% of patients had difference of movement of 10^{0}.

DISCUSSION

DISCUSSION

Though the technique has gained popularity in the last 20 years, its use was first reported by Clayton Parkhill in the year 1897. Henry Lambote popularised it in Britain in 1903. However, due to complication related to pin track infection at the site of insertion, the technique lost its popularity. The earlier instruments did not permit rotation and axial alignment. Dr Hoffmann in 1937 first produced pins with threads to achieve a superior purchase on the bone. He also developed clamps that were adjustable, helping to correct rotation and angulation. Illizarov of Russia used this principle and devised a ring external fixation device for superior purchase on the bone with ability not only to achieve axial angular and rotational correction but also to lengthen the tissues simultaneously. He is the father of the new concept of 'Histogenesis'. The concept is that slow, gradual, controlled distraction on the injured tissues stimulates formation of osteoblast cells from the parent pleuripotent mesenchymal cells. The basic fibrous tissue, mainly the ligaments, thus gradually distracted

produce normal collagenous structure. Because of its ability to continuous repair.

Dr. B.B. Joshi et al (1988) developed a simple light external fixator system for use in hand injuries, Dr. Joshi used this external fixator system in more than 150 cases of crush injuries of hand involving soft tissue and bone in varying degree of severity. He found this assembly to be very effective in stabilizing the skeleton in functional position to allow soft tissue, assessment and subsequently soft tissue healing.

After creating the planned frame, neutralize gravitational, rotational and angulatory forces, and maintain the digit and hand in functional position so, even the bones that are not in anatomical alignment will at least retain their axial alignment. The uninjured portion of the extremity is permitted to move and act without hindrance, further helping the soft tissues to heal by improving circulation and reducing lympho-venous stasis.

When the hand suffers a crushing injury tissues are affected in variety of ways. The process and transportation of the patients if done properly minimize

the insult. But if this procedure is rough the viable tissues are allowed to kink thus further jeopardising the already precarious blood supply.

It has been our observation that simple and neat frames are far more likely to succeed than complex ones. It is of paramount importance to keep a spaces of 5 to 7 mm between clamp and skin. This distances is adequate to allow wound and pin track care. Post procedure oedema can also undue discomfort. Increasing this distances would increase the free bending stretch of the wires compromising the stiffness of the frame.

On presentation at the hospital rough handling and contact with cleaning chemical irritant like H_2O_2 further damage the hand, commonly used method of treatment are stablization of fracture withK-wire and supporting the limb with POP slab or wire splints or limited internal fixation with plates, each of these procedures has inherent difficulties as devitalisation may take place and adequate stability may not provided.

The JESS extended hand frame offers stabilization by fixation of available intact skeleton without further devitalization. The simplicity of the procedure, the

emmens versatility and the possibility of readjustment at subsequent time confers in this system the unique possibility of achieving excellent result even in average hands.

Sir Reginald Watson Jones observed that "Colles' fracture of radius usually occurs in women, fractures of the metacarpals, only a few inches away, occur nine times out of ten in men". Most of the patients were young men.

In our study 16 cases of (JESS) fixator was applied in hand injuries. The maximum population was between 31-40 years age group and male to female ratio was 15:1

Sir Reginald Watson Jones observed different modes of injury in 100 patients, 32 patients, were injured in (crush) injuries of various type, 30 in road traffic accident, 23 by falling on to the hand and 15 in other ways. In crush injuries 28 out of the 32 in this series occurred at work, affecting the left hand in 17 patients, the Right hand in 13 patients and both hands in two patients, 25 had compound fractures. They were all men and none had other injuries elsewhere that is to say these were purely hand problems in working men.

Butt, in a review of 390 patients with hand fractures selected at random from the files of the workmen Compensation Board of Ontario, found that 35 had multiple fractures, the distribution being: thumb 4, index finger 4, middle 16, ring 24, little 18.

Mode of injury in our study were mainly fall of heavy objects (50%) followed by thresher injury (19%). It has been brought into the notice that most of the patients coming to the Orthopaedic Department having hand injury are working in the stone crushing set ups, in Bundelkhand region.

Most of the patients were admitted on the same day of injury. In cases of compound injuries, wound was thoroughly cleaned, especially if dirty machinery and thresher had crushed the hand. The surrounding intact skin was cleaned first with antiseptic cleansing agents and the open wound then cleaned more gently with a wet swab. Wound debridement was done before applying fixator, most of the compound injuries required split thickness skin graft later on.

Most common type of assembly used in our series was distractor, (37.5%) followed by extended hand frame

(Basic hand frame) (13%). Most of the wound healed with in 15 days. In follow up many of our patients, unfortunately, came from very impoverished backgrounds with poor personal hygiene. They were unable, in their circumstances, to keep the dressing clean in such patients each pin track is covered with gauze soaked in povidine iodine. 75 percent of fixators were removed after 30 days, two fixator after one month and rest within 6 weeks.

Most common complication observed at the time of fixator removal was presence of deformity due to restriction of movements. Pin track infection was seen in three cases (19%) one patient had delayed union. Osteomyelitis was observed in one case only. We evaluated the movements of different small joints at the time of fixator removal, at four weeks and later at six weeks. Most of the movements were severely restricted at the time of removal of fixator. The problem was dealt with active and passive physiotherapy.

At the final follow up 69% of M.P. joint regained their full monement. More than 20^0 degree of difference from uninvolved ray was present in only 19% of patients.

Recovery of movement of proximal interphalangeal joint was poorer as compared to metacarpo-phalangeal joint. 37% of patients had difference more than 10. In distal interphalangeal joint about 37% of the patients had 20^0 differences of movements from the normal.

The thumb demands a seperate consideration (functionally thumb is 40% of the hand). Apart from its functional importance anatomical peculiarities of the thumb place additional demands on the frame used. We dealt with seven cases of thumb injuries, three cases were fractures at the base of the first metacarpal, two cases of transverse fracture of the shaft of Ist metacarpal, one case was M.P. dislocation and one case was of fracture of neck of the first metacarpal. All the three cases of fractures at the base of first metacarpal were treated by distractor. Reduction and full range of MP joint movement of thumb was achieved at final follow up.

One case (case no. 16] of two weeks old volar dislocation of MP Joint of Lt thumb, satisfactory reduction was achieved by gradual distraction and good range of movements was also achieved.

In interphalangeal joint of thumb about 58% of patients had difference of movement of around 10^0 from the normal.

CONCLUSION

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With the use of thin and smooth wires placed away from the site of injury, in a stable configuration created by an exoskeleton of connecting system and link joints. JESS provides a stable skeletal environment adding rapid healing of soft tissues.

Limiting the frame configuration to the involved bone alone allows immediate mobilization of the adjacent joints, facilitates circulations and prevent lympho-venous stasis leading to lesser incidence of infections. Since mobilization keeps the gliding structures moving, functional restoration is expedited.

JESS is simple, versatile, light fixator system with a vast modularity and with tremendous potential. It is a very good system for maintaining the joint space better in intra-articular fractures. JESS is very much effective in reducing old neglected dislocations by slow distractions. It is also very effective in providing soft tissue stabilization in severe crush injuries of the hand. In these injuries on a later date split skin grafts and flaps can be performed and maintained. In comminuted fracture of

the base of metacarpals, peri-articular fracture around interphalangeal joints, maintenance of bone length, better stabilization of bone segment and better cosmetic results can be achieved from this system.

In cases of bone loss better maintenance of length was achieved. The patients hand can be immobilized in functional position so chances of stiffness in non-functional position is much less as compared to immobilization in POP slab.

This system also help in regular cleaning and dressing of wounds much easily without disturbing the stability of the bony architecture as compared to POP slab, which are to be removed again and again prior to dressing.

Few problems in inserting K-wire, specially in a grossly swollen and crushed hand, were faced in this study. We also faced difficulty in assembling the fixator if K-wire were not properly placed. Being invasive procedure, there are chances of pin track infection, and tethering of tendons. There is a possibility of neurovascular and soft tissue damage. If the frame construction is loose as it quite commonly happens due

to loosening of link joints malunions of the small bones may occur.

In multiple fractures of phalanx JESS frame hinder the physiotherapy of nearby fingers.

Because of above mentioned reasons and advantages offered by JESS in hand injury, we found it is of great value in salvaging and restoring hand functions.

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MASTER CHART

S.N	NAME	Age (years)	Sex	Mode of Injuries	Simple/ Open	Duration of Injuries	Ray Involved	Joint Involved			Fractures				JESS Frame used
								MP	PIP	DIP	M	PP	MP	DP	
1	Mahboob	16	M	Fall of Heavy object	Open	< 1 day	R4	-	-	-			4		Unilateral Frame
2	Parwati	30	F	Fall of Heavy object	Open	8 days	L2	-	2	-					Distracture
3	Gaj Raj	30	M	Crush injury RTA	Open	< 1 day	R4, 5	5			5	45	-	-	Ray Frame
4	Rinku	18	M	Fall of Heavy object	Simple	4 days	R1	-	-	-		1	-	-	J Frame
5	Bhajan Lal	16	M	Thresher	Open	< 1 day	R3, 4, 5	5	3		5	4, 3	-	-	Ray Frame
6	Kamlesh	30	M	Fall of Hard object	Open	2 days	L3	-	-	-	-	3	-	-	Unipalaner Dorso oblique frame
7	Nathu Ram	52	M	Hard object (Lathi)	Simple	2 days	R3, 4, 5				3, 4, 5				Reinforcement -II Metacarpal hold frame
8	Babu Pal	44	M	Crush injury (RTA)	Open	1 day	L1				1				First web space frame with Distracture.
9	Man Mohan	32	M	Fall of Heavy object	Simple	< 1 day	L1				1				First web space frame with Distracture.
10	Mool Chand	23	M	Fall on hand	Simple	6 days	R5					5			Distractore
11	Saleem	20	M	Hard object with L W	Open	2 days	L2					2			Delta Frame
12	Devi Das	32	M	Crush injury Trapped in btween door	Open	< 1 day	R1					1			Bilateral Frame
13	Ajay Sharma	26	M	Thresher injury	Open	< 1 day	L1,2,3, 4	3, 4			1, 2, 3	2,3,4			Ext Hand Frame
14	Ramesh	30	M	Fall of Hard object	Simple	< 1 day	L1				1				First web space Frame with Distracture.
15	Ramcharan	35	M	Thresher injury	Open	< 1 day	R4, 5				5, 4	4			Ext Hand Frame
16	Ayodhya	45	M	Hard object (Lathi)	Simple	14 days	L1	1			-	-	-	-	Distractore

Cases No.	Final evaluation of loss of movement				Complication					Duration of Pre-op-Hospitalization (days)	Duration of post op Hospitalization (days)	Time of fixator removal days
	MP (in degree)	PIP (in degree)	DIP (In Degree	IP In Thumb (In Degree)	Pin Track Infection	Oedema	Skin Necrosis	Loosning of Link joints	Delayed union			
1	0	40	20	-	-	+	-	-	-	1	4	21
2	0	40	20	-	+	-	-	+	-	1	3	21
3	20	10	20	-	-				-	1	27	40
4	0	-	-	10	-					1	3	30
5	20	30	30	-	-	-			-	1	20	30
6	0	10	10	-	-					2	7	30
7	10	10	10	-	-			+		1	8	30
8	0	-	-	10	-					1	9	30
9	0	-	-	10	-					1	7	30
10	0	20	20	-	-					1	3	21
11	0	10	30	-	-					1	5	21
12	0	-	-	40	-				+	2	20	38
13	30	50	50	30	+	+	+	+	-	1	30	45
14	0	20	10	20	-					1	3	30
15	40	60	40	-	+	+	+	+	-	2	30	45
16	0	0	-	10	-	-	-	-	-	2	7	21 days

SUMMERY

Hand injuries are common in working men and may loss of income to the patients and his family, and loss of production for his employers and his country.

Fortunately, an early return to work is generally the best treatment for the fracture as well as the patient. Once enough movement has been obtained for him to carry out his job, further progress can be expected with use.

Hand trauma has been increasing rapidly in recent years due to changes in the human environment, particularly in the home, work place, travel and leisure activities. Both the urban and the rural population are affected, the latter because of growing mechanisation specially in agriculture, industry and transport.

Dr Alfred B Swanson has put it very well : Hand fractures can be complicated by deformity from no treatment and both deformity and stiffness from poor treatment. This suggests that we must choose the treatment which is most appropriate to each particular fractures. Fracture of hand are the most frequent of all fractures. These fractures frequently involve more than one bone of hand and hence intra-articular extension, may be associated with dislocation and are usually involving the soft tissue extensively. In most of these

cases conservative treatment leads to malunited fractures, unreduced dislocation and poor soft tissue care. Intra-medullary fixation may lead to rotational instability, telescopy and intra-medullary infection.

The use of plates and screws in hand has been shown to incite an intense fibrotic reaction with scarring, not conducive to smooth functioning of gliding structures in the hand. One indication for the use of plates and screw would be in re-implantation and reconstructive micro-vascular surgery.

Though the technique has gained popularity in the last 20 years, its use was first reported by Clayton Parkhill in the year 1897. Henry Lambote popularised it in Britain in 1903. However, due to complication related to pin track infection at the site of insertion, the technique lost its popularity. The earlier instruments did not permit rotation and axial alignment. Dr Hoffmann in 1937 first produced pins with threads to achieve a superior purchase on the bone. He also developed clamps that were adjustable, helping to correct rotation and angulation. Illizarov of Russia used this principle and devised a ring external fixation device for superior purchase on the bone with ability not only to achieve axial angular and rotational correction but also to lengthen the tissues simultaneously. He is the father of the new concept of 'Histogenesis'. The concept is that slow, gradual, controlled distraction on the injured

tissues stimulates formation of osteoblast cells from the parent pleuripotent mesenchymal cells. The basic fibrous tissue, mainly the ligaments, thus gradually distracted produce normal collagenous structure. Because of its ability to continuous repair.

Dr. B.B. Joshi et al (1988) developed a simple light external fixator system for use in hand injuries, Dr. Joshi used this external fixator system in more than 150 cases of crush injuries of hand involving soft tissue and bone in varying degree of severity. He found this assembly to be very effective in stabilizing the skeleton in functional position to allow soft tissue, assessment and subsequently soft tissue healing.

After creating the planned frame, neurtralize gravitational, rotational and angulatory forces, and maintain the digit and hand in functional position so, even the bones that are not in anatomical alignment will at least retain their axial alignment. The uninjured portion of the extremity is permitted to move and act without hindrance, further helping the soft tissues to heal by improving circulation and reducing lympho-venoustasis.

When the hand suffers a crushing injury tissues are affected in variety of ways. The process and transportation of the patients if done properly minimize the insult. But if this procedure is rough the viable

tissues are allowed to kink thus further jeopardising the already precarious blood supply.

It has been our observation that simple and neat frames are far more likely to succeed than complex ones. It is of paramount importance to keep a spaces of 5 to 7 mm between clamp and skin. This distance is adequate to allow wound and pin track care. Post procedure oedema can also undue discomfort. Increasing this distance would increase the free bending stretch of the wires compromising the stiffness of the frame.

On presentation at the hospital rough handling and contact with cleaning chemical irritant like H_2O_2 further damage the hand, commonly used method of treatment are stabilisation of fracture with K-wire and supporting the limb with POP slab or wire splints or limited internal fixation with plates, each of these procedures has inherent difficulties as devitalisation may take place and adequate stability may not provided.

The JESS extended hand frame offers stabilization by fixation of available intact skeleton without further devitalization. The simplicity of the procedure, the emmens versatility and the possibility of readjustment at subsequent time confers in this system the unique possibility of achieving excellent result even in average hands.

Most common complication observed at the time of fixator removal was presence of deformity due to restriction of movements. Pin track infection was seen in three cases (19%) one patient had delayed union. Osteomyelitis was observed in one case only. We evaluated the movements of different small joints at the time of fixator removal, at four weeks and later at six weeks. Most of the movements were severely restricted at the time of removal of fixator. The problem was dealt with active and passive physiotherapy.

At the final follow up 69% of M.P. joint regained their full movement. More than 20 degree of difference from uninvolved ray was present in only 19% of patients.

Recovery of movement of proximal interphalangeal joint was poorer as compared to metacarpo-phalangeal joint. 37% of patients had differeance more than 10^{0}. In distal interphalangel joint about 37% of the patients had 20^{0} differences of movements from the normal.

The thumb demands a separate consideration (functionally thumb is 40% of the hand). Apart from its functional importance anatomical peculiarities of the thumb place additional demands on the frame used. We dealt with seven cases of thumb injuries, three cases were fractures at the base of the first metacarpal, two cases of transverse fracture of the shaft of first metacarpal, one case was M.P. dislocation and one case was of fracture of neck of the first metacarpal. All the

three cases of fractures at the base of first metacarpal were treated by distractor. Reduction and full range of MP joint movement of thumb was achieved at final follow up.

One case (case no. 16) of two weeks old volar dislocation of MP Joint of Left thumb, satisfactory reduction was achieved by gradual distraction and good range of movements was also achieved.

In interphalangeal joint of thumb about 58% of patients had difference of movement of around 10^0 from the normal.

With the use of thin and smooth wires placed away from the site of injury, in a stable configuration created by an exoskeleton of connecting system and link joints. JESS provides a stable skeletal environment adding rapid healing of soft tissues.

Limiting the frame configuration to the involved bone alone allows immediate mobilization of the adjacent joints, facilitates circulations and prevent lympho-venous stasis leading to lesser incidence of infections. Since mobilization keeps the gliding structures moving, functional restoration is expedited.

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This system also help in regular cleaning and dressing of wounds much easily without disturbing the stability of the bony architecture as compared to POP slab, which are to be removed again and again prior to dressing.

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